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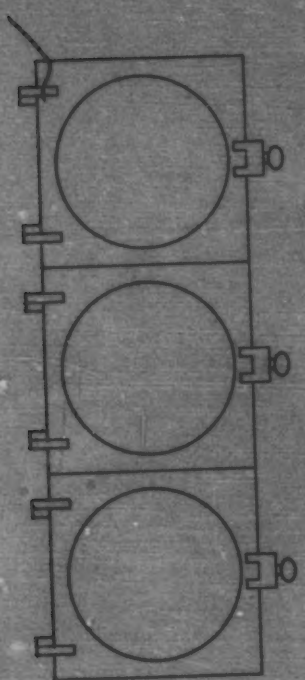
INSPECTOR'S MANUAL FOR TRAFFIC SIGNAL CONSTRUCTION



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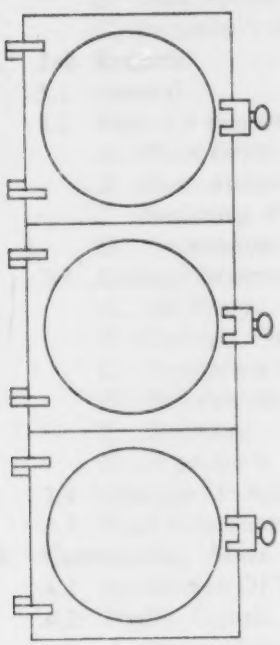

August, 1985

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CHAPTER 1
Purpose

The objective of this Manual is to provide engineers and inspectors with the assistance necessary to assure successful installation and completion of traffic signals and other highway electrical projects in compliance with the contract documents. Potential problem areas and possible results of poor workmanship are also discussed. The Manual is a supplement to the standard specifications, plans, specifications and special provisions. In case of conflict between the Manual and any of the project documents, the usual priority stated in Item 5.5 of the Standard Specifications will be used. This Manual is not intended to replace or supersede contract documents.

Good workmanship, construction planning, attention to plan details, and awareness of conditions of the project can avoid interruptions during construction and provide a working project that has as few maintenance and operational problems as possible. This Manual assumes that planning has been careful and field work prior to planning has been adequate. Plans are prepared based on guidelines laid out in the Manual of Uniform Traffic Control Devices, The Construction Manual, the Design Division Manual and the Maintenance Division Manual.

To properly perform their duties and responsibilities, readers using this Manual may find it necessary to refer to other publications or sources of information. Sources of valuable information are the Institute of Transportation Engineers, the National Electrical Manufacturers Association, the National Electrical Code, and the International Municipal Signal Association.

Since this Manual is intended as a reference work, some subjects are treated in several places so they can be easily found. Though it is intended as a reference, it was also arranged so that the prospective reader could read it in its entirety, and this is recommended.

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CHAPTER 2
Preconstruction

2.1 General

Every contract construction project is a joint venture between the Department and a Contractor. The best way to begin is when both parties know what they can expect from the plans and from the other party. A Pre-Construction Conference will help all parties involved understand their obligations and other expectations. The Department personnel should work with the Contractor to quickly complete the job while complying with the plans and specifications and without sacrificing the quality of work or materials. Employees of the Contractor should cooperate with the Department by complying with the contract documents willingly.

2.2 Site Inspection

Prior to the letting of a project, the prospective bidder should inspect the project location in the company of the resident Engineer. The Engineer should be very careful to give all prospective bidders the same information and should keep accurate notes of the prospective bidder's questions and their answers. More details relating to Plans, Specifications and Project Site Inspections are listed in the Construction Manual, Item 101.4. The Inspector assigned to the project should accompany the Resident Engineer on the Site Inspections.

2.3 Coordination with Other Agencies

Close coordination with any agency that may be involved with, or affected by the project will be good for all. This coordination will in most cases involve communication with these agencies at least three times; (1) during the planning phase, (2) at the preconstruction meeting and possibly during construction, and (3) at project completion. The agency which will take over maintenance of the signal should be contacted before and invited to attend the final inspection. That agency should also be told (in writing) at what time their responsibility will begin.

2.4 Pre-Construction Conference

An Agenda for a Pre-Construction Meeting is covered in the Construction Manual under Item 101.4. The meeting should be well planned and reviewed beforehand. The time for the meeting should be agreed upon with the Contractor, local law enforcement agencies, concerned governmental agencies, emergency units (fire, EMS, etc.), utility and/or pipeline owners (if involved), railroads, and possibly others as necessary.

A roster of all present should be made, and detailed notes should be taken during the meeting. The planned sequence and timed phases of work should be covered in detail by the Contractor and reviewed by the Resident Engineer. Names and phone numbers of all those who may be called in an emergency should be made available here.

2.5 Traffic Control Plan

The Department's Traffic Control Plan (TCP) should be covered in detail by the Resident Engineer during the pre-construction meeting. If the Contractor wishes to use a different TCP he must submit it to the Resident Engineer for review and approval by the Department. The Department's and Contractor's Responsible Persons should be named, their duties should be outlined, and close cooperation should be initiated during the preconstruction meeting.

Inspections of the project relating to conformance to the Traffic Control Plan should be made on both a formal and informal basis both day and night. Administrative Order 32-79 (Traffic Safety in Highway and Street Work Zones) discusses the implementation of

the Traffic Control Plan, the required inspections, and the inspection reports.

2.6 Utilities

(a) *Planning Stage* - In the planning stage of the project all known owners of utilities within the limits of the project should be contacted and detailed locations of these utilities incorporated into the plans. After all known utilities are plotted on the plans, a site inspection should be made to determine if there may be obvious errors or new utilities not listed in the plans. Cuts and patches in pavement, curbs, and sidewalks; conduit ventpipes; valve boxes and manholes and some indicators of buried lines. A general note in the plans should be used to advise the contractor of the possibility of "existing but unknown utility lines"; and that "every effort has been made to indicate the location of known utilities, however, the contractor is responsible for the safety and protection of all utilities during the conduct of his operations."

(b) *Construction Stage* - During the construction stage, notifying the utility companies of planned work in the area of their lines may save much time and expense by preventing damage to lines. Many utility companies prefer to expose their own lines if necessary. Any unknown utilities discovered during construction should be accurately mapped, the location plotted on the final plans for future reference, and the locations given to the District Design Office and the Maintenance Office. If any utility locations are found to be different from that shown on the plans, then the Final Plans should indicate the actual location, and the utility owner should be notified of the findings.

2.7 Material Lists

The Inspector may have several materials lists to maintain on a project.

(a) *Contractor's Material List* - Section IV of the Materials and Test Division's Manual of Procedures outlines the requirements pertaining to the Contractor's submission of a list showing exact sources of all materials to be used on the project. The Manual also lists a schedule of minimum requirements of materials. This list should be cross checked with materials listed on the plans to insure proper testing and recording of all materials listed on the plans to insure proper testing and recording of all materials scheduled to be used in the job. The inspector should also check this list before making payment for any materials on hand but not in place.

(b) *State Forces' Materials List* - A list of Materials and/or Equipment to be furnished or installed by State Forces should be prepared and maintained by the Inspector. The coordination of securing, delivering and installing these items should be handled by the Inspector with regard to the Contractor's work and needs.

(c) *Inspector's Materials List* - This list would include the materials, equipment and supplies the inspector needs to perform the day to day inspection and record keeping for the project (This could range from note pads to concrete beam boxes, ticket books to hard hats, etc.)

CHAPTER 3
Job Records

3.1 General

Adequate records are essential for the administration of all construction projects. Chapter 3, "JOB RECORDS," of the Construction Manual (prepared by the Construction Division) should be used as a reference for information or answers to questions related to this subject.

The same job records are required on signal projects as on any roadway construction project. Monthly estimates, time statements, invoices and inspection reports of material received, and the project diary provide the usual documentation of job progress. The Inspector's job will be much easier if he has a good understanding of what he needs to maintain sufficient records.

The public has great expectations when they see signal poles being erected. It may be desirable for the contractor to do no work until he has all the materials on hand so that the public will not be confused about the expected completion date.

3.2 Prior to Beginning Work

There are several items of record that should be processed or confirmed before beginning work:

(a) *Work Order (letter)* - On a contract project the Contractor shall not begin work until a written "Work Order" is received by the Contractor from the Engineer.

(b) *Fund Authorized (Form 178)* - A fund authorization is issued by the Finance Division showing a breakdown of the allocation of funds to the various accounts for the project. Funds allocated for State Force Account work shall not be exceeded without prior approval.

(c) *Beginning Work Notification* - The Resident Engineer should send a letter to the Construction Division giving the date that construction began and naming the Project Engineer. He should attach a letter from the Contractor designating the Contractor's Superintendent. (Refer to Construction Manual 103.7A)

(d) *Prosecution of Work* - Before work begins, the Contractor must submit a schedule to the Engineer showing how the work will be done in order to finish on time. (Refer to Item 8.2 of the Standard Specifications, 1982 edition)

3.3 During Construction

(a) *The Diary* - The Resident Engineer or his authorized representative must keep a "Job Diary." This written record is a brief, day to day report of important events, activities and discussion which takes place on the project. (Refer to Construction Manual 103.6)

The diary can be helpful in finding mistakes and judging claims for extra work. Any accident occurring on a project should be described in detail in the Diary. The Diary is many times the only source of information available about vehicle accidents on the job site.

Any suggestions or direct orders to the Superintendent should be recorded in the Diary. Any inspections by District or Federal Agencies should also be recorded.

Weather conditions, nearby construction work, comments by local police or other officials on the job should be entered in the Diary.

(b) *Contract Time* - Contract time will begin on the date shown on the Work Order which is issued to the Contractor by the

Engineer. (Refer to 108.5 in the Construction Manual)

Time charges are recorded in the job diary. Any event that could show the progress of the job should be noted in the diary. During Test Periods, if all construction work is complete, no time is charged and "Test Period" is indicated each day in the Diary, on the monthly time statement, and on the Summary Time Statement for the Final Estimate. If any construction work is in progress during a test period then time is charged for each day that work can be performed. (Refer to Item 1.38 and Item 8 of the Standard Specifications)

(c) *Temporary Suspension of Work* - The Resident or District Engineer will have the authority to suspend work as he considers necessary and "Time Charge" will be suspended during such period. (See Construction Manual 108.4)

(d) *Test Periods* - Time charges may be suspended during operational test periods if all other work has been completed and the "Timed Test" is the only remaining item to be completed before the job is accepted.

(e) *Estimates* - The estimate is the means of paying the Contractor for contract work performed.

The Monthly Estimate is a partial payment and procedures for submitting the estimate are outlined in Construction Manual 109.5.

Monthly estimates must be based on actual work performed. The Contractor's breakdown of item cost is helpful to the Engineer in his preparation of the monthly estimates. This breakdown can be helpful in the event of Extra Work negotiations or claims after the job is completed. Monthly estimates are difficult to determine in system constructions. For example, traffic signals are usually paid as one Item even though that Item takes the whole construction period. The Engineer and Contractor should agree on a partial payment plan at the pre-construction conference.

A system of approved record keeping of materials, labor and equipment used on the project is required to determine the quantities for payment in both Monthly and Final Estimates. The Department's "Construction Records Manual' (1969 Edition and Revisions) is an accepted guide.

The Final Estimate and supporting papers should be prepared and submitted in accordance with the Finance Division's Manual of Instructions, Section IX.

(f) *Inspection Reports* - Item 6 "Control of Materials" of the Standard Specifications, 1982 Edition covers: Sources of Supply and Quality of Materials, Samples and Tests, Plant Inspection, Storage of Materials and Defective Materials. Item 103.7 of the Construction Manual is "Required Reports and Forms to be Submitted to Austin Office." Chapter 6 "Control and Inspection of Materials" of the Construction Manual covers: Job Control Tests, Record Tests, Storage of Materials Certificates from the Contractor, Test Reports, Guide Schedule of Sampling and Testing.

3.4 Changes or Additions to the Plans

The plans and specifications are supposed to provide for the construction of a complete project; however, sometimes certain conditions may require changes in the plans and specifications. The contract documents allow these changes under Item 4 "Scope of Work" of the Standard Specifications. Chapter 4 of the Construction Manual shows how to handle Field Changes, Extra Work, Supplemental Agreements and Memorandum Agreements. Plan changes must be approved before the contractor can proceed with any affected work.

The District Engineer may approve an Extra Work Order of $2,500.00 or less and must notify File D-6 of each such Extra Work Order. The Austin office must approve of all Extra Work Orders exceeding $2,500.00, *all* Field Changes, and *all* Supplemental Agreements.

See Item 104.4 of the Construction Manual for information about Memorandum Agreements.

3.5 Final Inspection

When, in the opinion of the Resident Engineer, the Contractor has fulfilled all requirements of the contract, the Resident Engineer shall notify the District Engineer and the agency who will assume maintenance responsibility that the project is ready for the Final Inspection. The party responsible for maintenance and the Resident Engineer should review the project together before the District Engineer accepts the project. Upon acceptance of the project by the District Engineer, the Contractor is notified and relieved of responsibility of the work. At the same time the party designated to assume responsibility for the maintenance of the signal should be notified (in writing). This notification should include the specific date and time of the maintenance responsibility transfer.

On some signal projects, involving several intersections, the plans and specifications may provide for the acceptance and/or transfer of individual intersections as they are completed.

CHAPTER 4
Construction Areas

4.1 Installation of Traffic Controls

The installation of traffic signals may consist of any or all of the following items: wood poles, mast arm supports, strain poles, pedestal poles, conduit and pull boxes, span wire signal heads, controllers, detectors and loops, computers, illumination and various incidental items required to provide a properly operating signal. This chapter discusses each of these areas to acquaint the inspector with some of the various terms normally used in traffic signal installations.

4.2 Traffic Signals

The types of structural supports normally used fall into one of four basic pole classifications, i.e. wood poles, steel strain poles, mast arm (cantilever) poles, or pedestal poles.

(a) *Wood Poles* - Wood poles are generally used as supports for span wire installations. These installations can span the intersection diagonally or perpendicularly to each approach roadway. The latter is commonly referred to as a Box-Type installation. Each wood pole received at the project site should be inspected before installation for checking, splitting and any other damage that may have resulted during delivery (see Specification Item "Timber Poles"). Wood poles shall be free of defects since the poles will be subjected to bending forces applied by the various attachment to the poles.

Methods vary for attaching span wires to wood poles. Attachment should be done in accordance with details shown in the project plans. If no such details are provided, Figures 4-1 and 4-2 provide typical methods for making span wire attachments to wood poles.

Wood poles should be checked for vertical alignment during installation to avoid having a completed project that has leaning poles. Leaning poles reduce the structural strength of the installation as well as provide an eyesore which may cause public criticism.

The strength or load carrying capabilities of a wood pole is dependent on two ingredients: (1) the stability of the soil in which the pole is placed and (2) the anchoring of the pole. The soil replaced around the wood pole after it is set into place should be compacted thoroughly to provide maximum stability to the pole. If unstable soil is encountered, or if the plans indicate, concrete should be placed around the pole to improve its stability. Guy cables are used to anchor wood poles. The two types of guy anchoring most commonly used are the standard angle and the sidewalk guys. The sidewalk guy method is normally used where space is limited and an acceptable angle cannot be obtained on the standard type guy. Typical examples of both type anchoring methods are illustrated in Figures 4-3 and 4-4.

All anchor cones or anchor devices should be placed securely in the ground to develop the correct amount of support to the wood pole. The slope of the guy cable determines the amount of load that can be carried by the installation. Since there are many variables that can affect the slope of the guy cables, specific slopes cannot be recommended here. However, for most traffic signal installations in a loamy soil, a slope between a 1:3 maximum slope, and a 1:1 desirable slope is acceptable. When the slope must exceed a 1:3 ratio, it is recommended that the sidewalk type installation be utilized. Where unstable

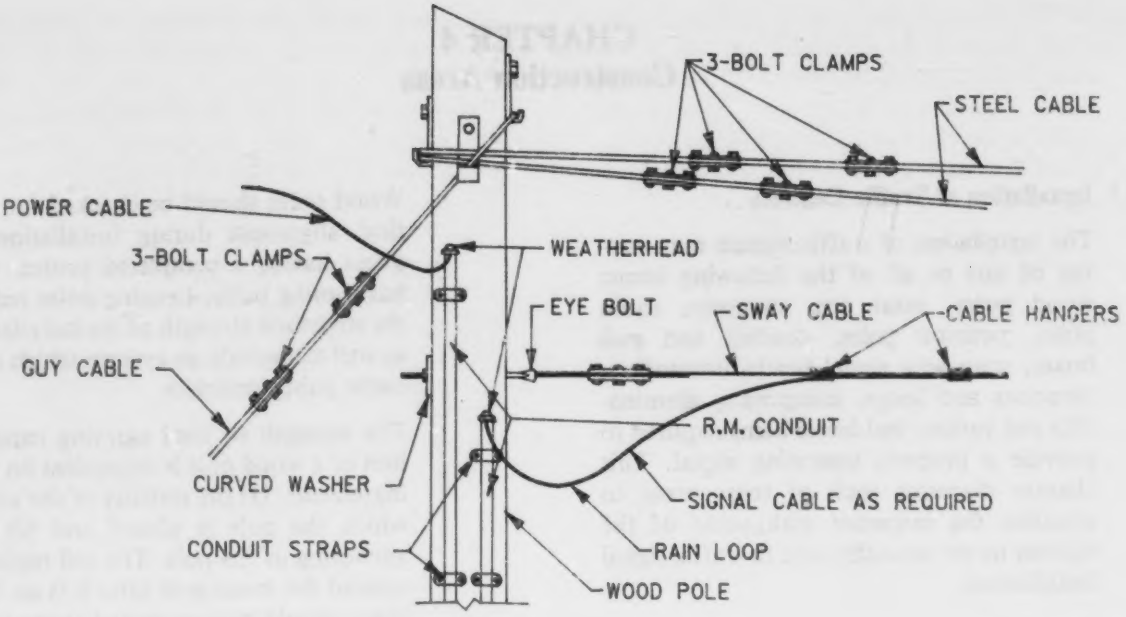


FIGURE 4-1

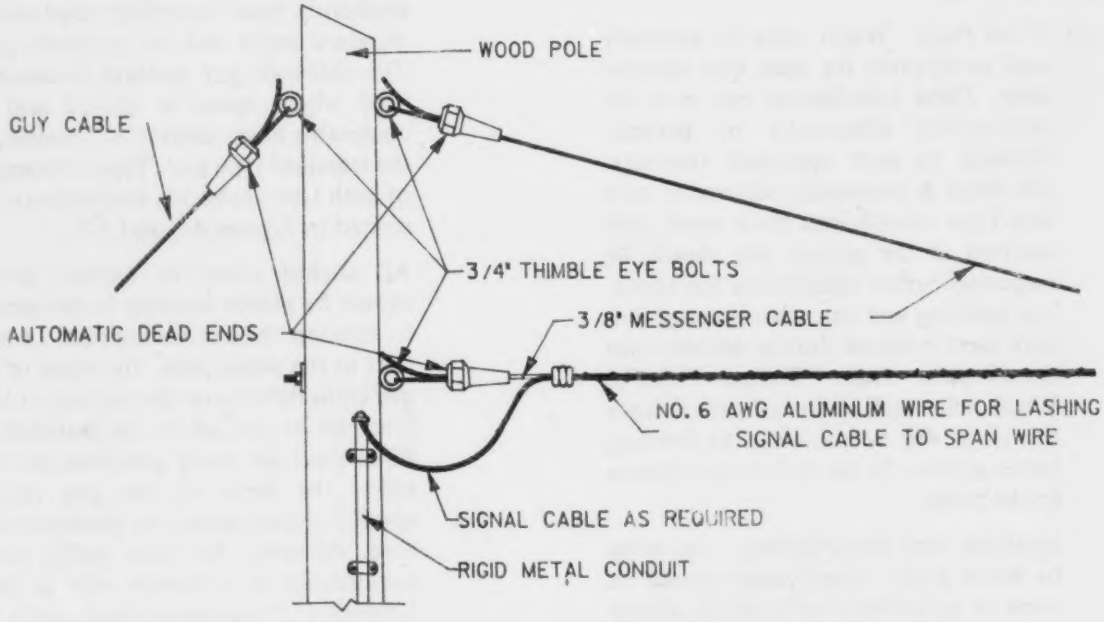
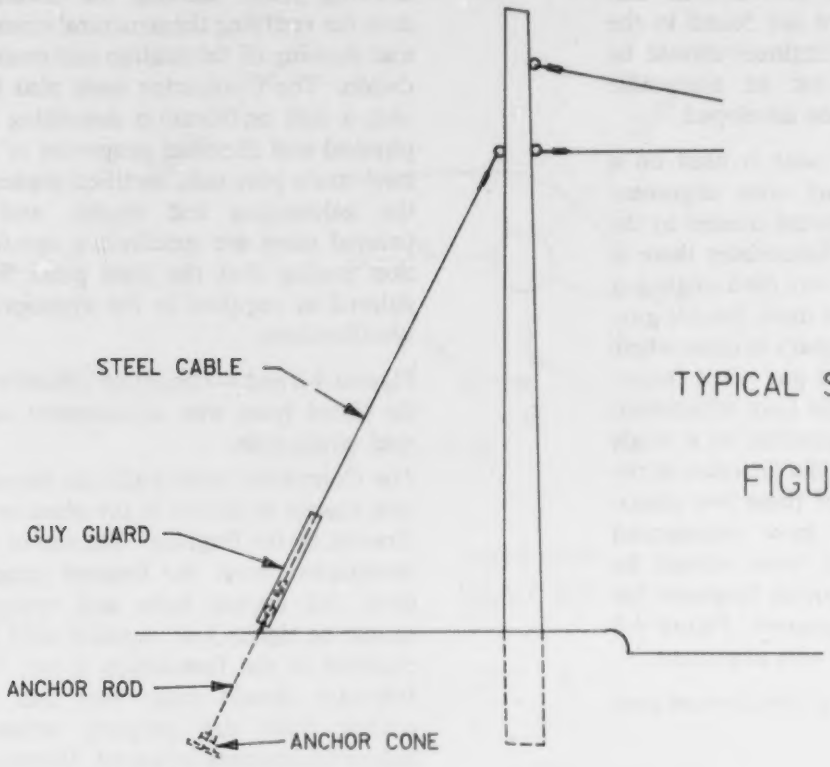
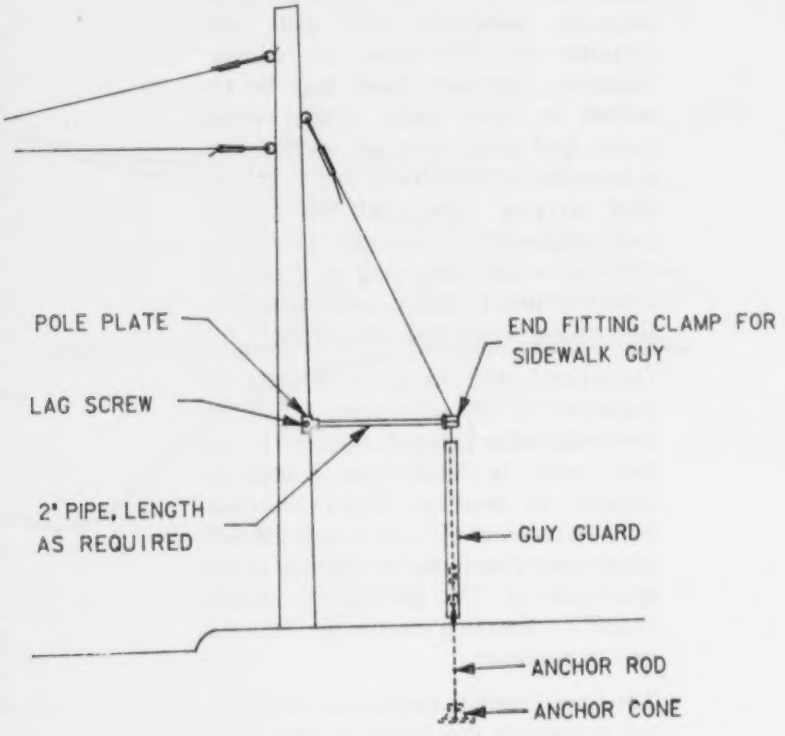


FIGURE 4-2



TYPICAL STANDARD GUY

FIGURE 4-3



TYPICAL SIDEWALK GUY

FIGURE 4-4

soil conditions are encountered and anchoring details are not found in the plans, the project Engineer should be notified in order that an acceptable anchoring plan can be developed.

When a single guy wire is used on a wood pole, the guy wire alignment should balance the forces created by the spans on the pole. Sometimes there is not enough right-of-way for a single guy wire and two must be used. Double guying may also be necessary in areas where the best slopes of the guy wires cannot be attained. A double span attachment to a pole can be supported by a single guy aligned opposite the direction of the "resultant" forces of these two spans. Installations which have unbalanced loading of the span wires should be evaluated by the Project Engineer for proper guy wire alignment. Figure 4-5 illusrates typical guy wire alignment.

Figure 4-7 illustrates a typical wood pole installation.

(b) *Steel Strain Poles* - Steel strain poles are normally associated with span wire installations. However, in certain instances, luminaire arms may be attached to these poles. Unlike wood poles, steel strain poles are anchored to a foundation with anchor bolts and the load carrying capacity of the pole is dependent upon the strength of the pole. All steel strain poles used on a project must conform in design to the specification "Steel Strain Pole Assembly."

Galvanized steel strain poles must be inspected for any galvanizing which has been scraped or chipped off down to the bare metal in fabrication, transit to project, or erection. These locations must be repaired with the proper galvanizing repair compound as required in the specifications. The galvanizing repairs should be done in a manner that leaves a neat appearance.

The Specifications require the Contractor to furnish the Engineer with shop drawing prints showing the necessary data for verifying the structural strength and showing all fabrication and erection details. The Contractor must also furnish a mill certification describing the physical and chemical properties of the steel strain pole unit, certified copies of the galvanizing test report, and if painted poles are specified, a certification stating that the steel poles were painted as required in the appropriate specifications.

Figures 4-6 and 4-7 illustrate typical traffic signal span wire attachments to a steel strain pole.

The Contractor must build the foundation exactly as shown in the plans or as directed by the Engineer. The top of the foundation must be finished exactly level. All anchor bolts and conduits should be rigidly held in place until the concrete in the foundation is set. The Inspector should make sure that the anchor bolts are properly oriented before the concrete is poured. Maximum strength of the strain pole installation is developed when two anchor bolts are being pulled in tension. If leveling bolts are used, bad orientation of the anchor bolts can result in one bolt in tension, one in compression, and two bolts acting as rockers. This condition will severely reduce the strength of the strain pole assembly.

When a single span installation is proposed, the anchor bolts are to be lined up with the span direction. When two different directions are spanned, the anchor bolts should be located along the resultant force axis. For span wire signal installations, this resultant force direction can be considered as one-half the internal angle between the span directions. If equipment is attached to one of the spans which unbalances the weight considerably, it may be necessary for the Engineer to determine the anchor bolt orientation. Figures 4-8 and 4-9 illustrate the proper alignment of anchor bolts.

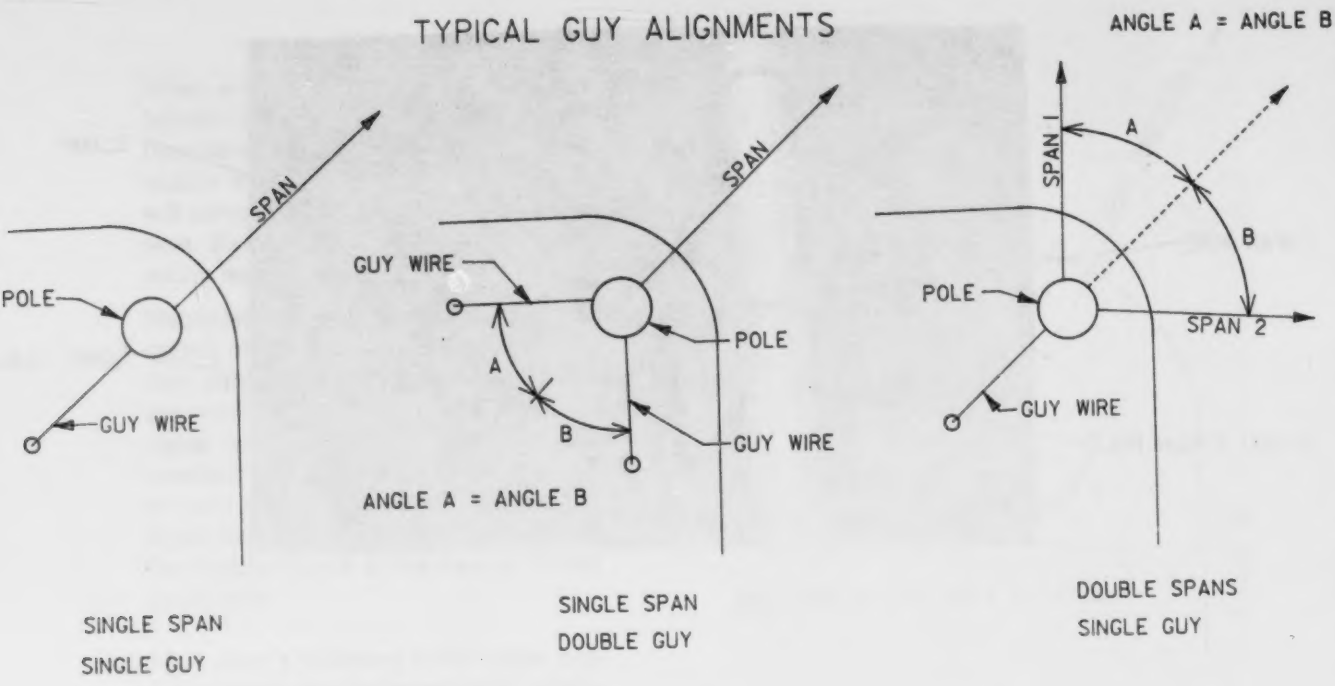


FIGURE 4-5

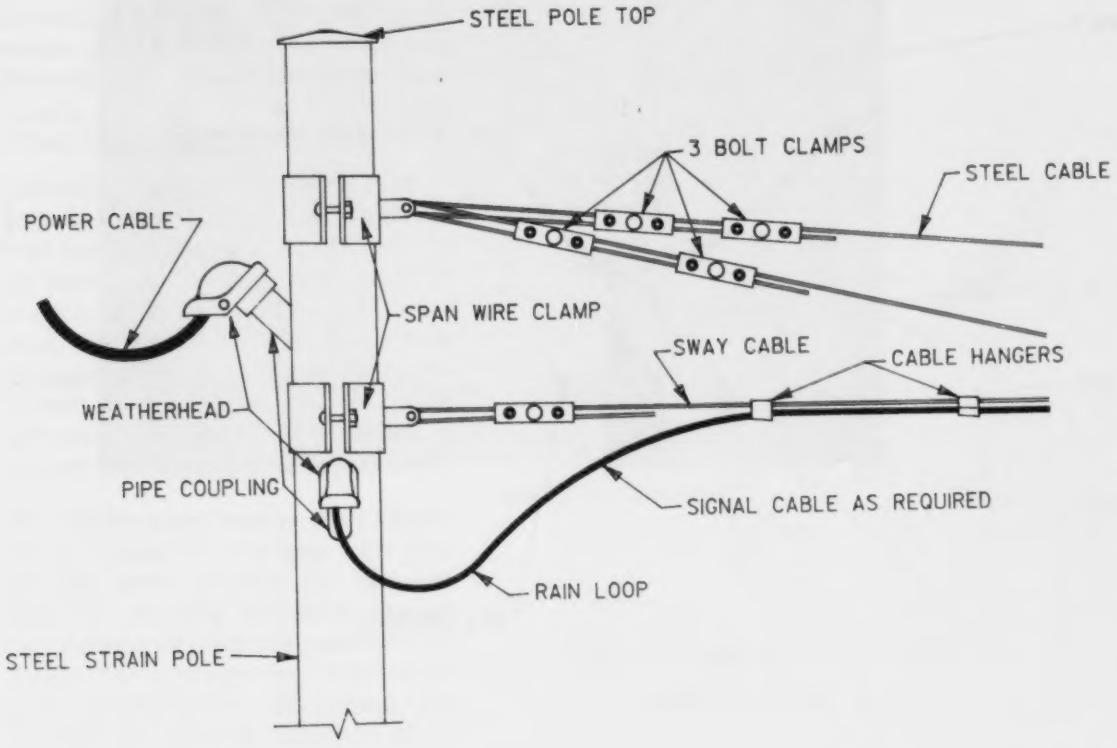


FIGURE 4-6

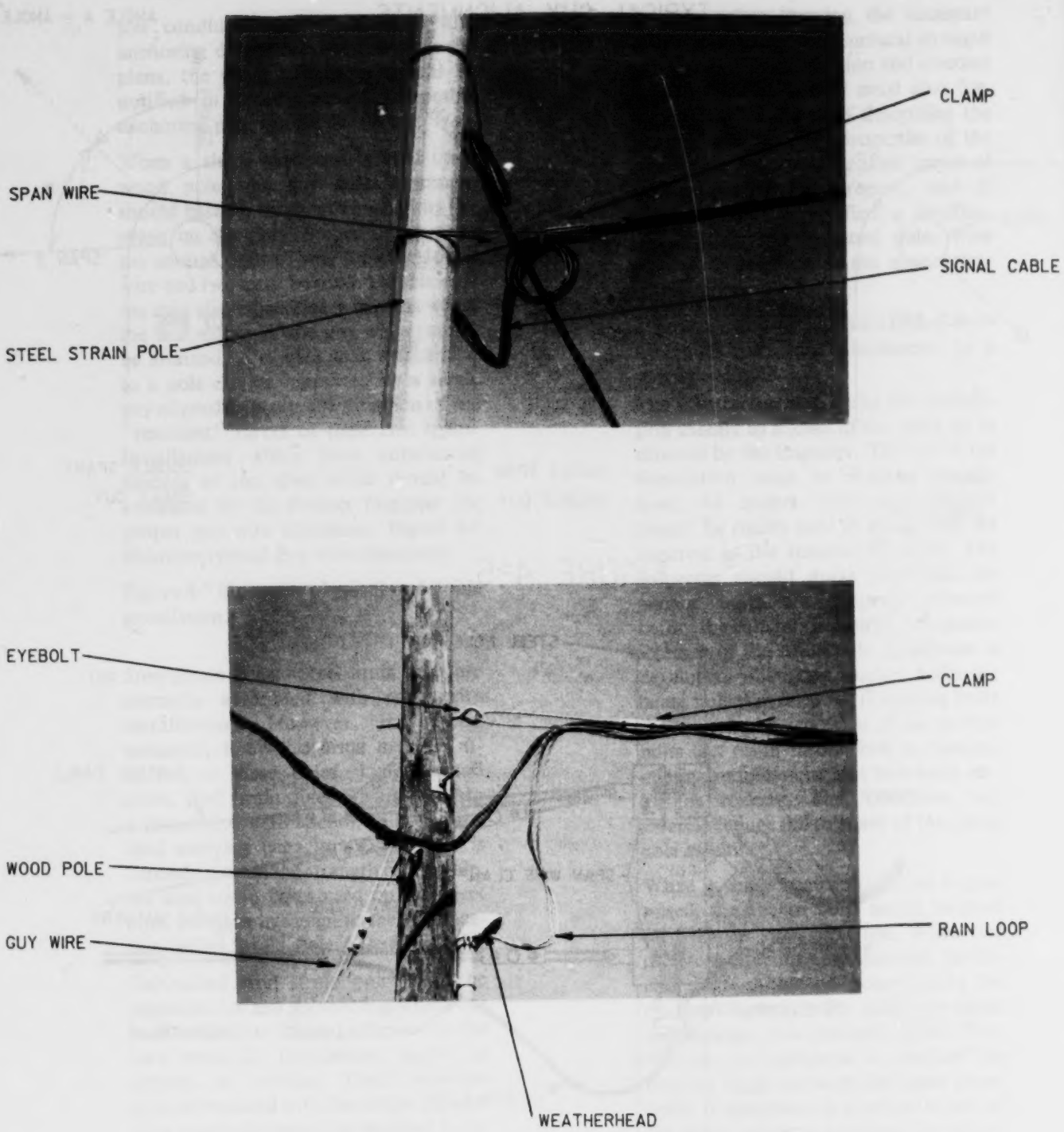

CLAMP
SPAN WIRE
SIGNAL CABLE
STEEL STRAIN POLE
EYEBOLT
CLAMP
WOOD POLE
GUY WIRE
RAIN LOOP
WEATHERHEAD

FIGURE 4-7

When leveling bolts are used, the space between the pole base and the top of the foundation should be filled with a good quality mortar after leveling. This filler will serve as a bearing pad for the strain pole. Figure 4-10 illustrates a steel pole with a mortar pad.

Electrical terminal blocks may be required by the plans at the base of the steel strain pole. When terminal blocks are required, electrical wiring from the signal controller will be wired into the terminal block and separate wiring will be used from the terminal block to the signal indications. Figure 4-11 illustrates the terminal block at the base of a steel strain pole.

(c) *Mast Arm (Cantilever) Poles* - Mast arm installations are self-supporting structures which have an arm projecting or cantilevered above the roadway to which signal heads are attached. The mast arm assembly is anchored to a foundation by means of anchor bolts. All mast arm assemblies received on the project must comply in design to the specification "Steel Mast Arm Pole Assembly."

Galvanized mast arm assemblies must be inspected for any galvanizing which has been scratched or chipped off down to the bare metal in fabrication, transit to project, or erection. These locations must be repaired with the proper galvanizing repair compounds as required in the specifications. The galvanizing repairs should be made in a manner that leaves a neat appearance.

The specifications require the Contractor to furnish the Engineer with shop drawing prints showing the necessary data for verifying structural strength and showing all fabrication and erection details. The contractor must also furnish mill certifications describing the physical and chemical properties of the steel mast arm pole assemblies, certified copies of the galvanizing test report, and

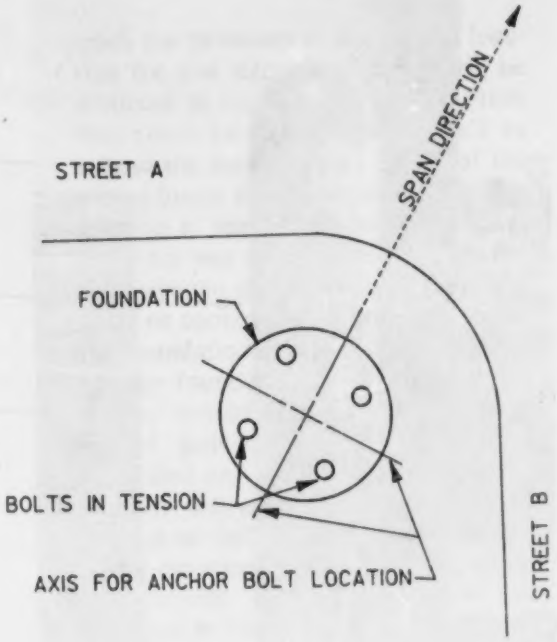


FIGURE 4-8

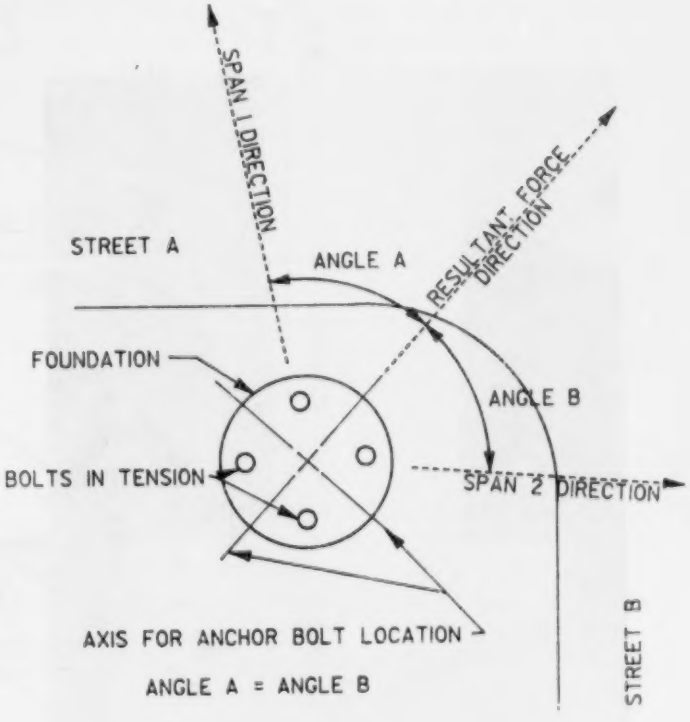


FIGURE 4-9

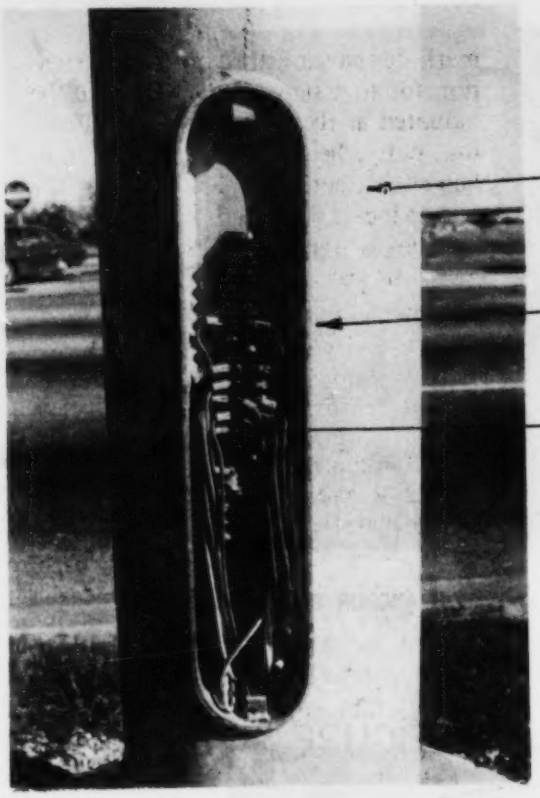
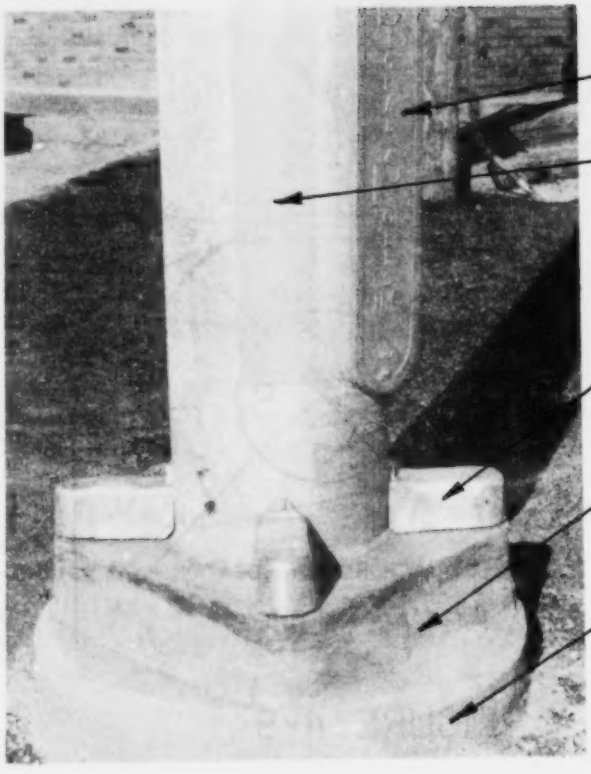


FIGURE 4-11



SHOE BASE

FIGURE 4-10

if painted poles are specified, a certification stating that the steel poles were painted in accordance with the appropriate specifications.

Unlike steel strain poles, mast arm assemblies are designed for certain arm lengths, loading and wind factors. Therefore, orientation of the anchor bolts is not necessary unless a special design is encountered. The design of these units take into account the pole base plate, the transformer base when specified and the anchor bolts.

The actual dimensions of the mast arm assemblies limit the margin of error that the Inspector has in locating the foundations. The most important thing is that the signal heads be placed in the best position. Therefore, in order to locate the foundation, the Inspector should mark the pavement at the desired location for that signal head which will be mounted at the end of the arm. From that point, he should measure back to behind the curb the plan length of the arm to locate the foundation. When this location is impractical because utilities are in the way or for some other reason, the Inspector should use his best judgement or contact the Engineer to locate the foundation. After the best location for the foundation is decided, the Inspector should take elevation shots at critical points. Using these relative elevations and the fixed dimensions of the mast arm assembly, the elevation of the top of drill shaft can be calculated. These elevations are necessary to obtain the desired vertical clearances as specified in the plans. Figure 4-12 provides an illustration of the procedure for locating foundations.

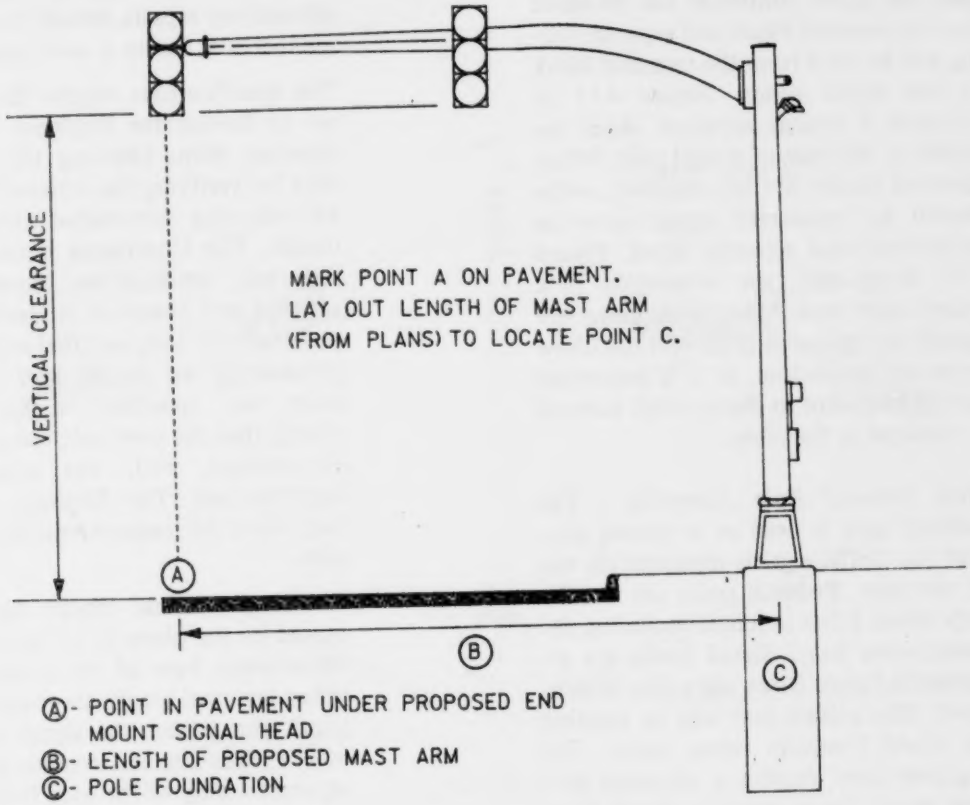

VERTICAL CLEARANCE
MARK POINT A ON PAVEMENT.
LAY OUT LENGTH OF MAST ARM
(FROM PLANS) TO LOCATE POINT C.
A
B
C
Ⓐ- POINT IN PAVEMENT UNDER PROPOSED END MOUNT SIGNAL HEAD
Ⓑ- LENGTH OF PROPOSED MAST ARM
Ⓒ- POLE FOUNDATION

FIGURE 4-12

Figures 4-13 and 4-14 show typical single and double mast arm installations.

Mast arms are attached to the pole with either a rigid type connection or a clamp-on type connection. The clamp-on connection provides some flexibility in adjusting the mast arms to the height. If a rigid type connection is furnished, the position and alignment cannot be changed; therefore, the anchor bolts must be located properly in the foundation so that when the mast arm assembly is set in place, the alignment will be correct. Figures 4-15 and 4-16 give typical examples of both types of attachments.

Electrical terminal blocks may be required by the plan specifications to be located in the transformer base or in the base of steel poles. When terminal blocks are required, electrical wiring from the signal controller will be wired into the terminal block and separate wiring will be used from the terminal block to the signal heads. Figure 4-11 illustrates a typical terminal block installed at the base of a steel pole. When terminal blocks are not required, wires should be connected using screw-on connectors and securely taped. Figure 4-17 shows this type connection in a transformer base. Many times plans will specify no splices at all or will not allow screw-on connectors, so it is important for the Inspector to check which method is required in the plans.

(d) *Steel Pedestal Pole Assembly* - The pedestal pole is used as a vertical support for traffic signals mounted on top of the pole. Pedestal poles are usually only about 8 feet in length including the transformer base. Signal heads are attached to the pole by a slip collar attachment. Slip collars may not be suitable for 4-and 5-section signal heads. The Engineer may require a standard side pole mount on a longer pedestal pole.

Pedestal poles are attached by anchor bolts to a foundation. A typical pedestal pole is shown in Figure 4-18.

The foundations for pedestal poles must be constructed to the size, length, and design shown in the plans or as directed by the Engineer. The top of the foundation must be finished exactly level. All anchor bolts and conduit should be rigidly held in place until the concrete in the foundation is set.

Galvanized steel pedestal poles must be inspected for any galvanizing which has been scratched or chipped off down to the bare metal in fabrication, transit to project, or erection. These locations must be repaired with the proper galvanizing repair compounds as required in the specifications. The galvanizing repairs should be done in a manner that leaves a neat appearance.

The specifications require the Contractor to furnish the Engineer with shop drawing prints showing the necessary data for verifying the structural strength and showing fabrication and erection details. The Contractor must also furnish mill certifications describing the physical and chemical properties of the pedestal pole unit, certified copies of the galvanizing test report, and if painted poles are specified, a certification stating that the steel pole was painted in accordance with the appropriate specifications. The Engineer or Plans may waive this requirement for standard pipe.

Electrical terminal blocks may be required by the plans to be located in the transformer base of the pedestal pole. When terminal blocks are required, electrical wiring from the signal controller will be wired into the terminal block and separate wiring will be used from the terminal block to the signal indications.

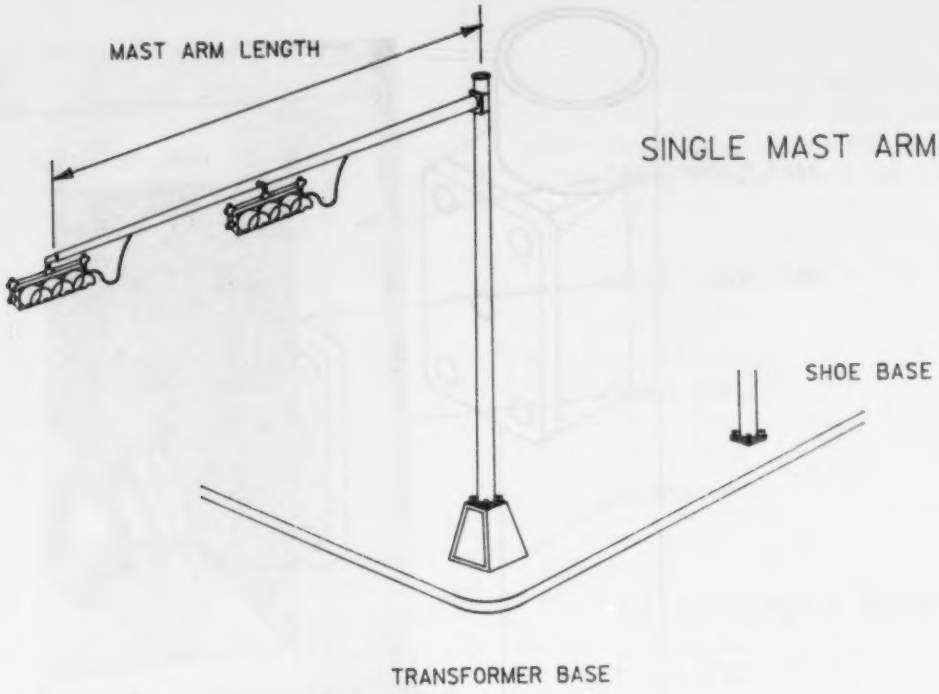


FIGURE 4-13

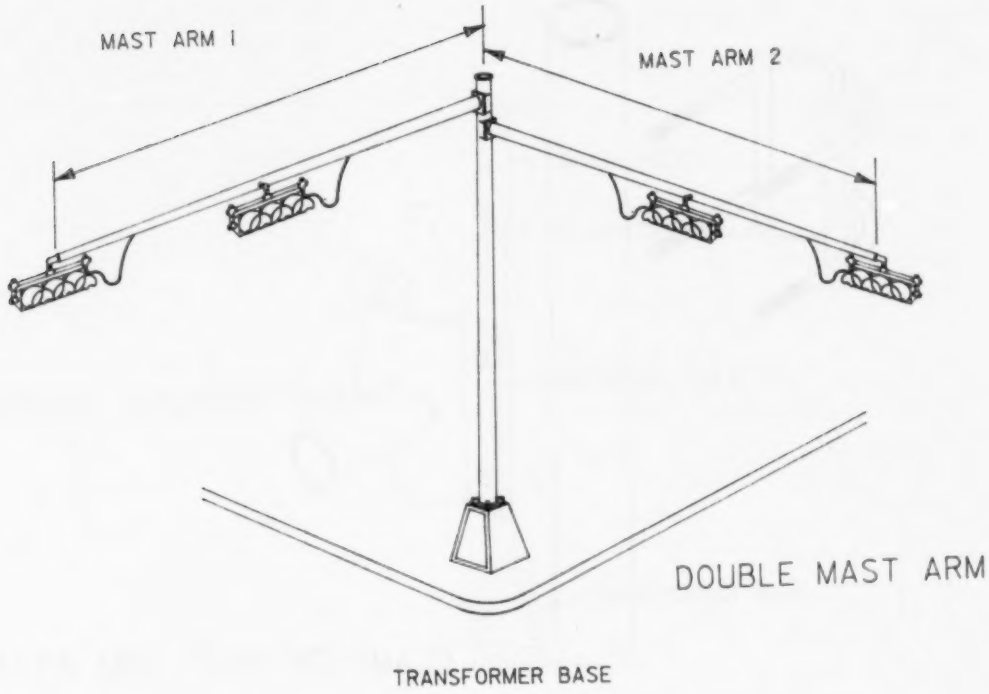
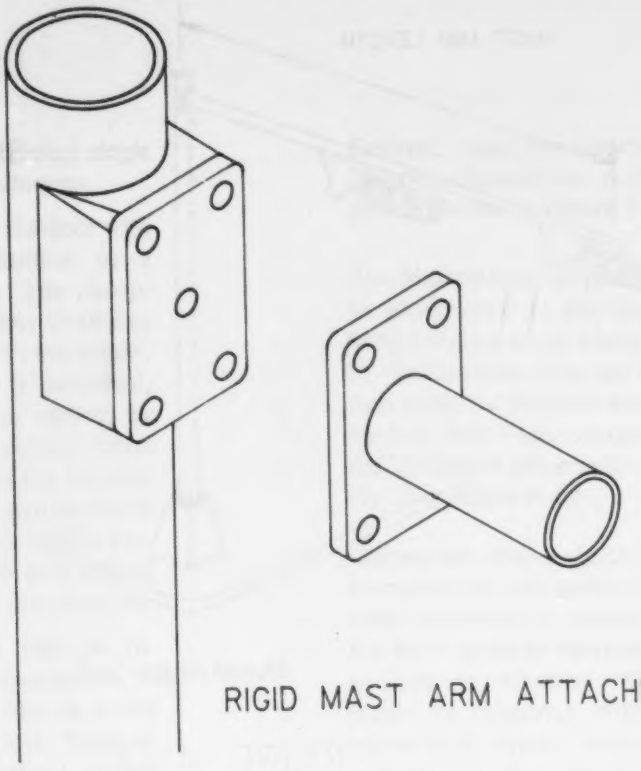
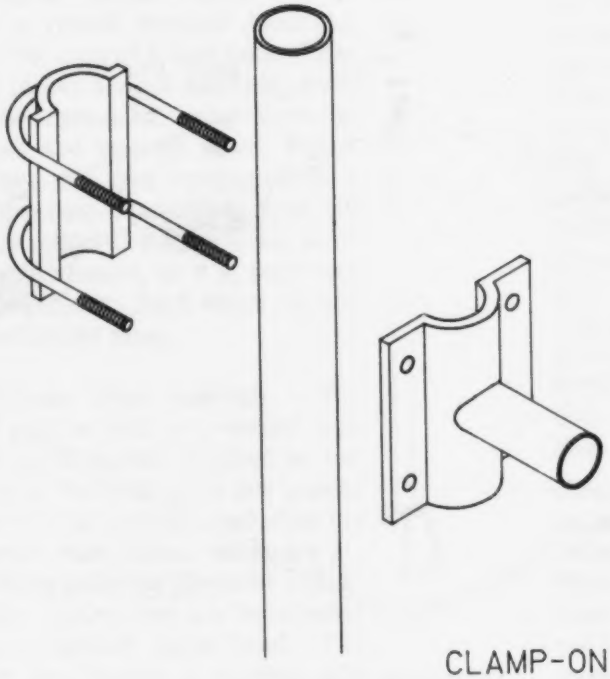


FIGURE 4-14



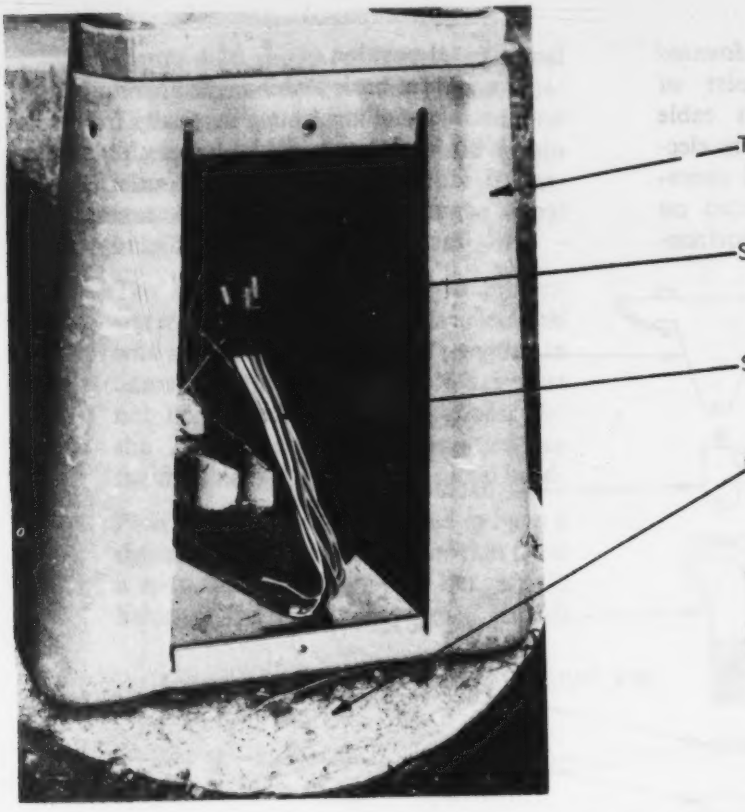
RIGID MAST ARM ATTACHMENT

FIGURE 4-15



CLAMP-ON MAST ARM ATTACHMENT

FIGURE 4-16



TRANSFORMER BASE
FIGURE 4-17

PEDESTAL MOUNTED SIGNAL

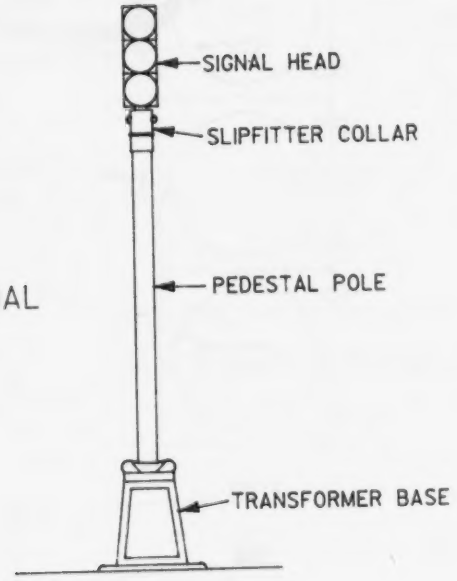


FIGURE 4-18

(e) *Traffic Signals, Span Wire Mounted* -Span wire installations consist of suspending signal heads from cable spans and providing the necessary electrical wiring to make the signal operational. Signal heads are mounted on span wire in either a vertical or horizontal position.

Three basic attachments are required for a signal head hung vertically from span wire: (1) a span wire hanger, (2) balance adjuster and (3) a wire outlet. An expanded illustration of the necessary attachments are shown in Figure 4-19.

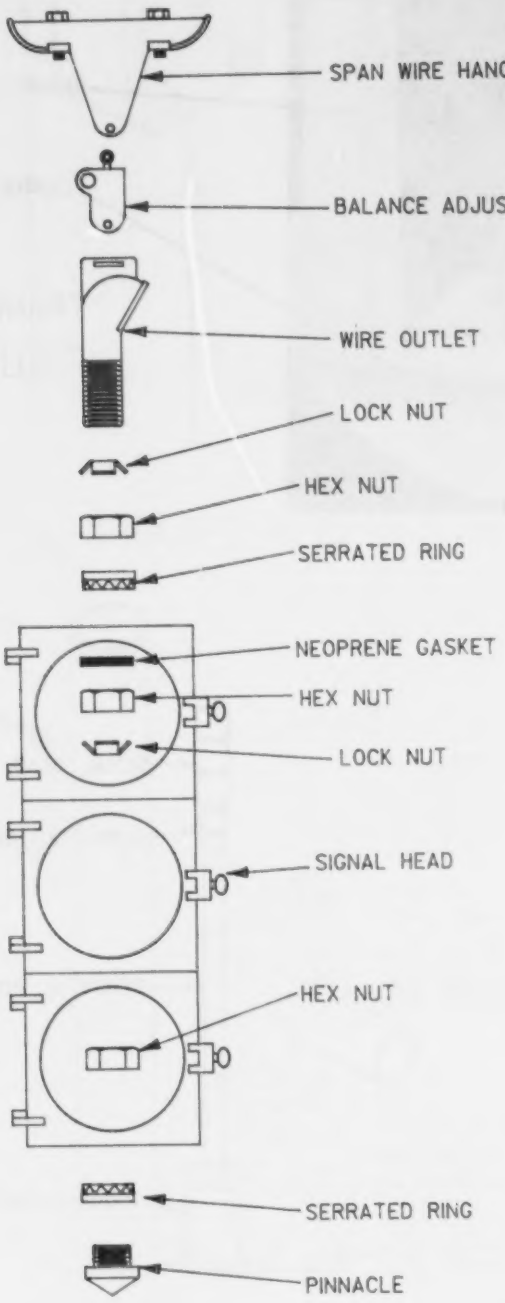


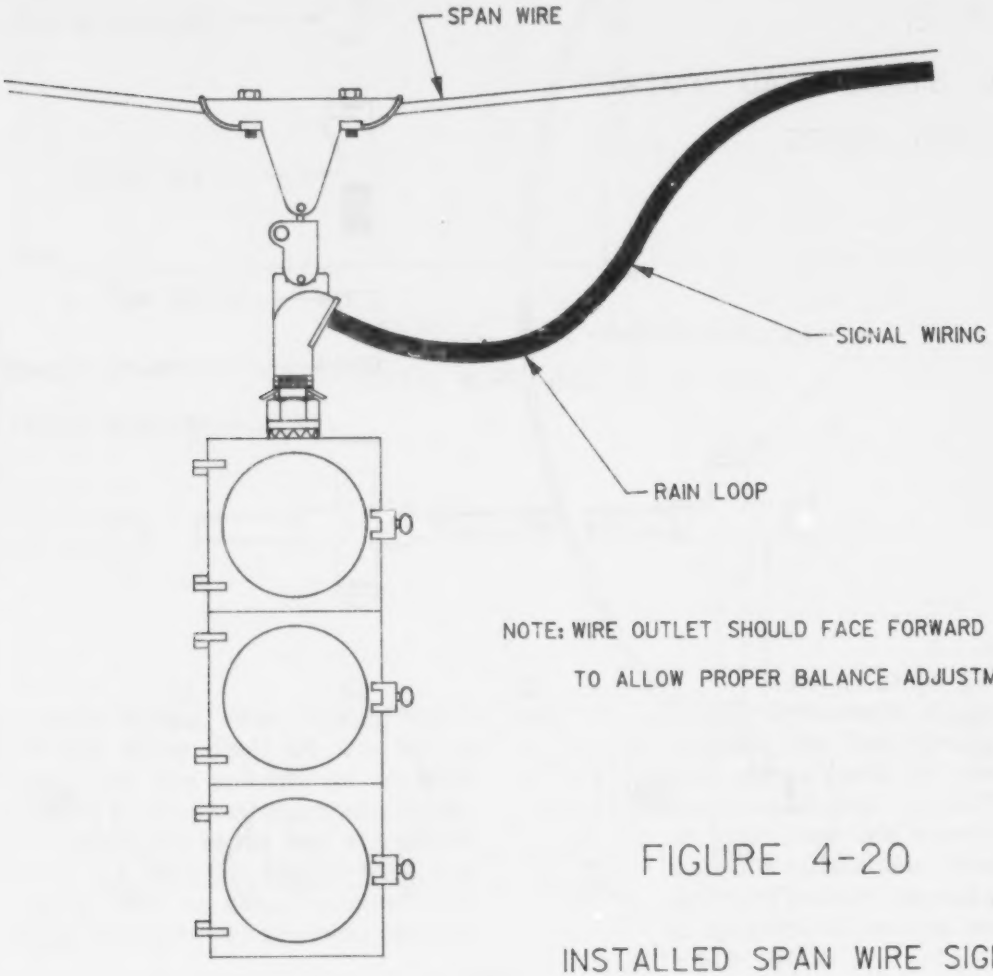
FIGURE 4-19

Figure 4-20 shows an assembled signal head hung vertically from a span wire. The Inspector should make sure that when the traffic signal is wired a rain loop is placed in the wiring at the entrance to the wire outlet on the signal head.

The rain loop is necessary to prevent water from traveling along the electrical wire into the signal head and resulting in damage to the signal faces. Wires must not be spliced outside the heads, but should be run continuously and tied into the terminal strip inside the signal head.

Four attachments are required to hang a signal head in a horizontal position from a span wire: (1) span wire hanger, (2) balance adjuster, (3) wire outlet, and (4) a horizontal bracket assembly. A typical illustration of these attachments is shown in Figure 4-21. Horizontal heads should be mounted so that the signal face door hinges are on the bottom which allows for the door to open downward and remain open when changing bulbs or servicing the head.

Consideration must be given to the sag of the steel cables in a span wire installation. The amount of sag in the cables determines the forces applied to the signal poles. The sag should not be less than 5 percent of the total span length. Example: an 80-foot span requires at least 4 feet of sag. Figure 4-22 illustrates a typical span wire installation with the proper span wires and sag.



NOTE: WIRE OUTLET SHOULD FACE FORWARD
TO ALLOW PROPER BALANCE ADJUSTMENT

FIGURE 4-20

INSTALLED SPAN WIRE SIGNAL

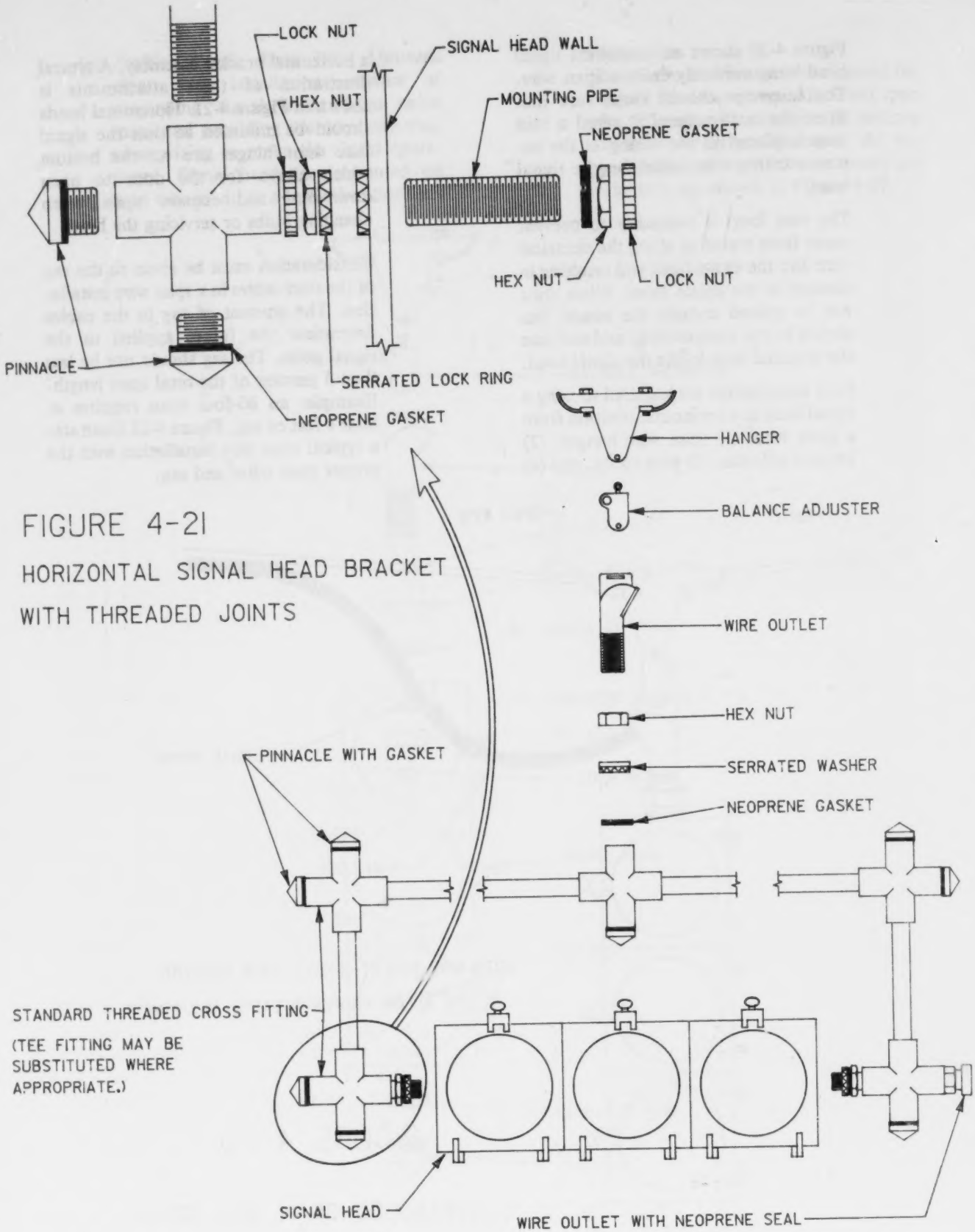
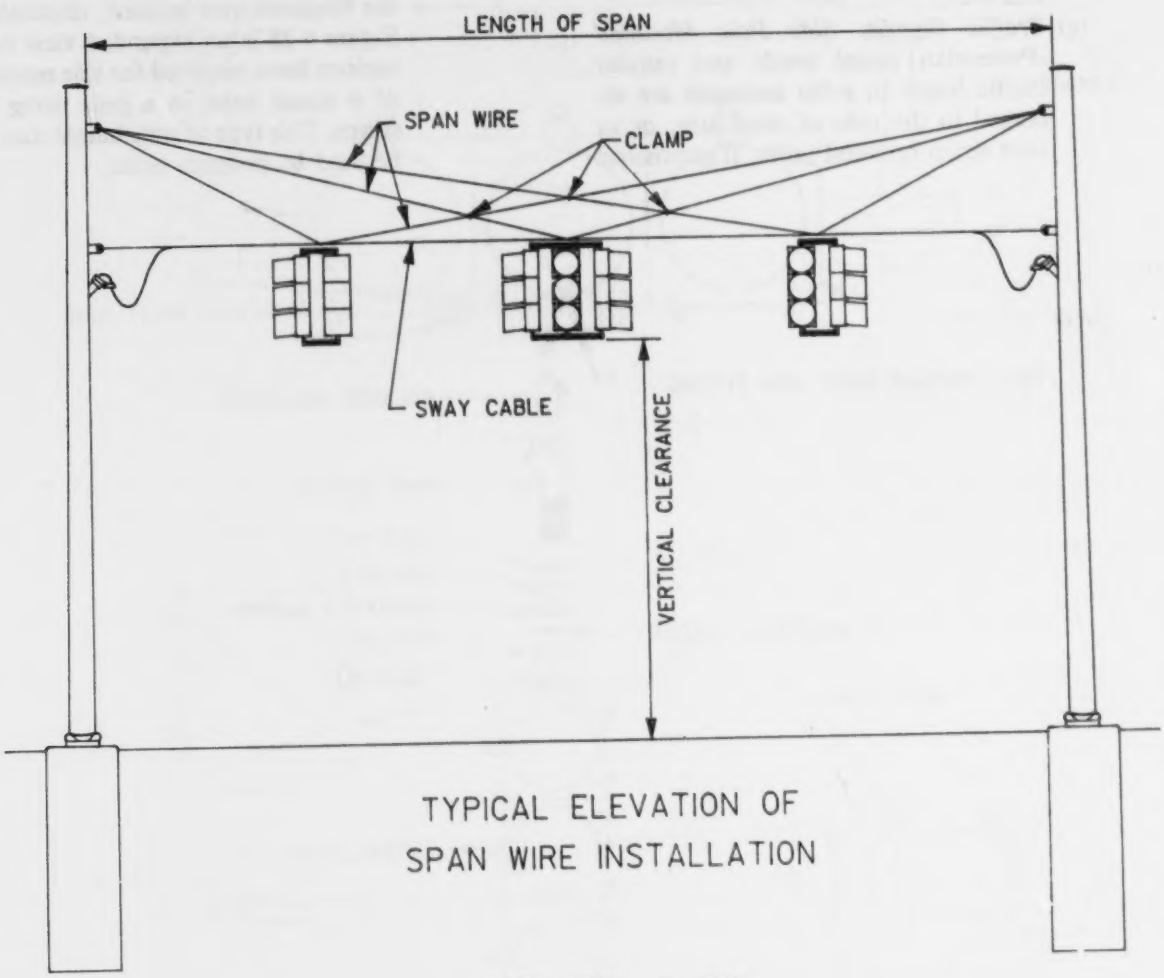


FIGURE 4-21

HORIZONTAL SIGNAL HEAD BRACKET WITH THREADED JOINTS



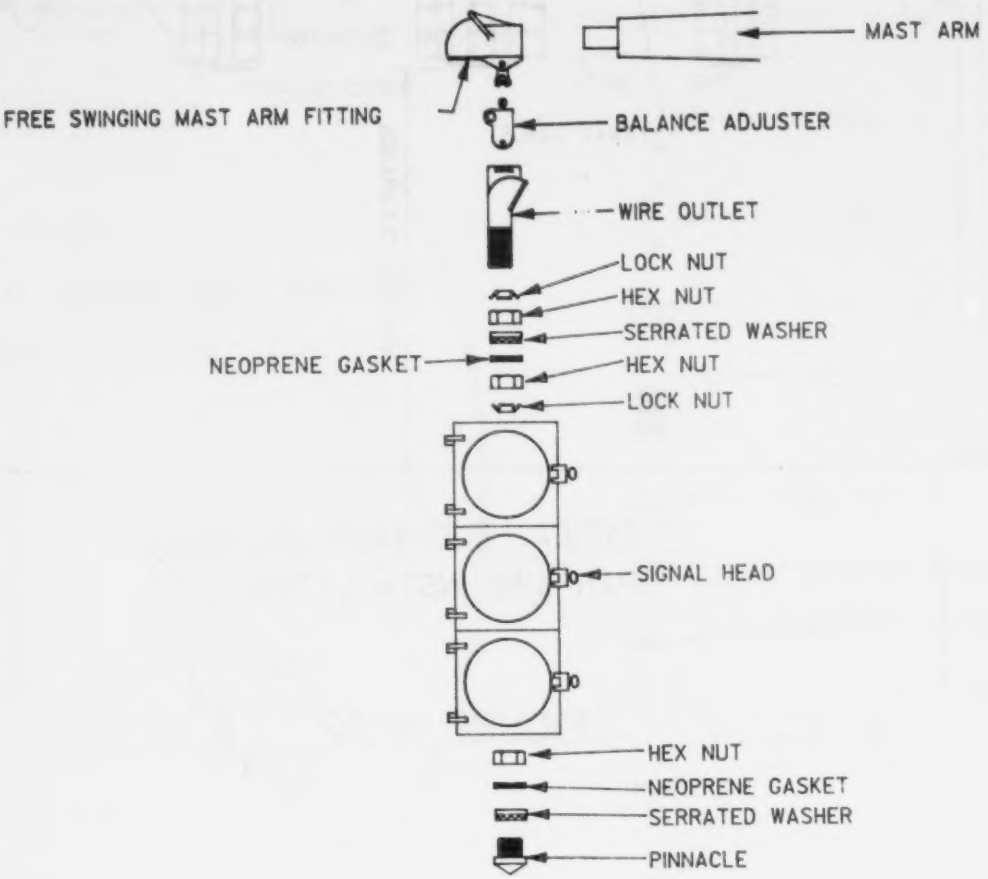
TYPICAL ELEVATION OF
SPAN WIRE INSTALLATION

FIGURE 4-22

(f) *Traffic Signals, Mast Arm Mounted* -Traffic signal heads are attached to mast arms and are done in the same manner as span wire attachment, except the attachment to the mast arm differs from the span wire hanger. Mast arm signals may be either mounted with fixed mounts or with free swing mounts. Usually, horizontally aligned heads are mounted with fixed mounts and vertically aligned heads are mounted with free swing mounts. Two different types of attachments are encountered with mast arm installations. Attachments at the end of the mast arm and attachments at midpoint of the arm are required.

Figures 4-23, 4-24, and 4-25 illustrate typical end of mast arm mounts. Midpoint attachments vary but typical illustrations are shown in Figures 4-26 and 4-27.

(g) *Traffic Signals, Side Pole Mounted* -Pedestrian signal heads and regular traffic heads in some instances are attached to the pole of mast arm, or to steel strain or wood poles. If provisions have not been made in the poles to mount these signal heads, they may be strapped to the pole with stainless steel bands, or other methods approved by the Engineer may be used. Illustrated in Figure 4-28 is an expanded view of the various items required for side mounting of a signal head to a pole using steel straps. This type of attachment may also be used on pedestal poles.



FREE SWINGING MAST ARM END

FIGURE 4-23

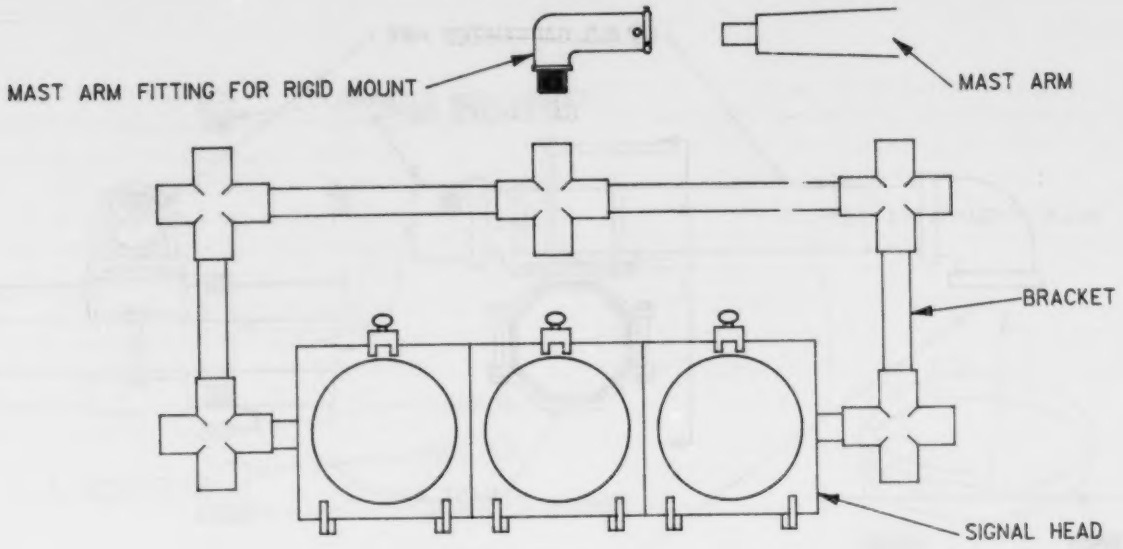


FIGURE 4-24

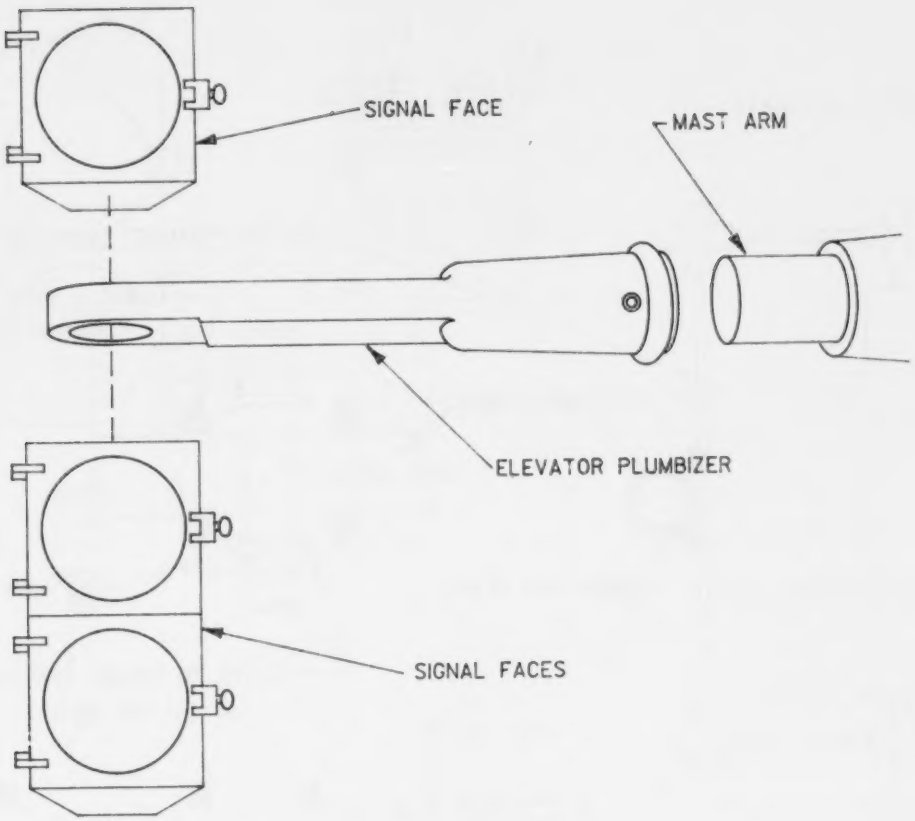


FIGURE 4-25

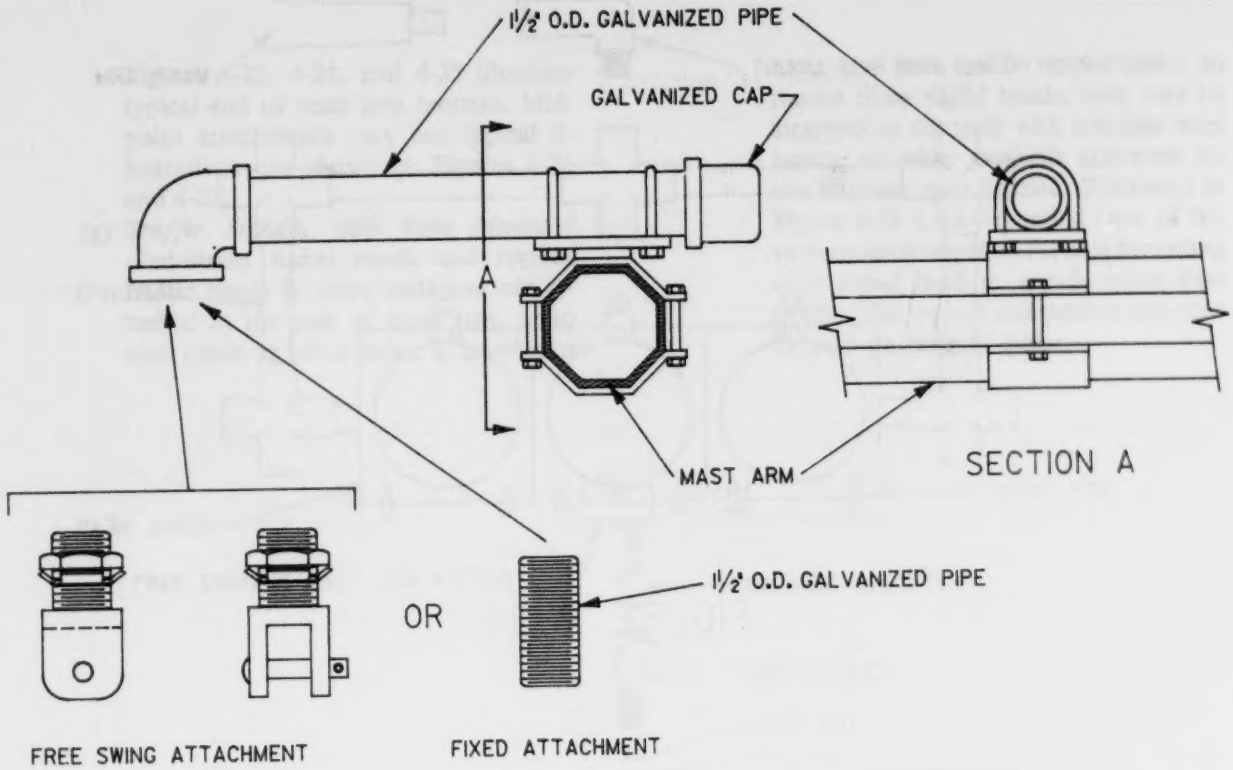


FIGURE 4-26

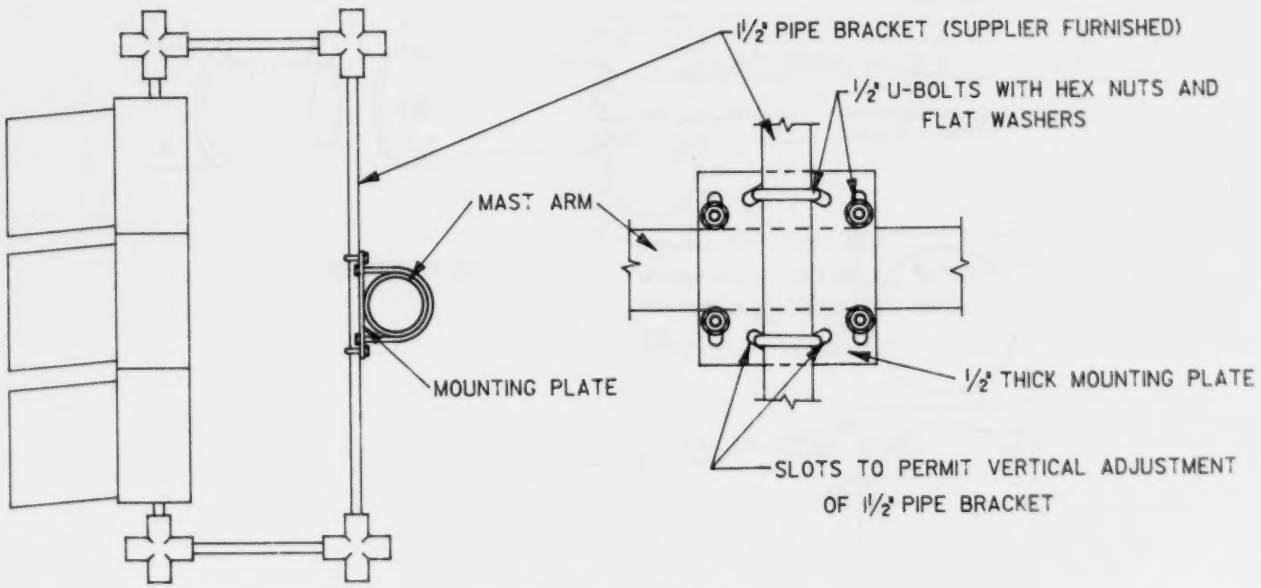
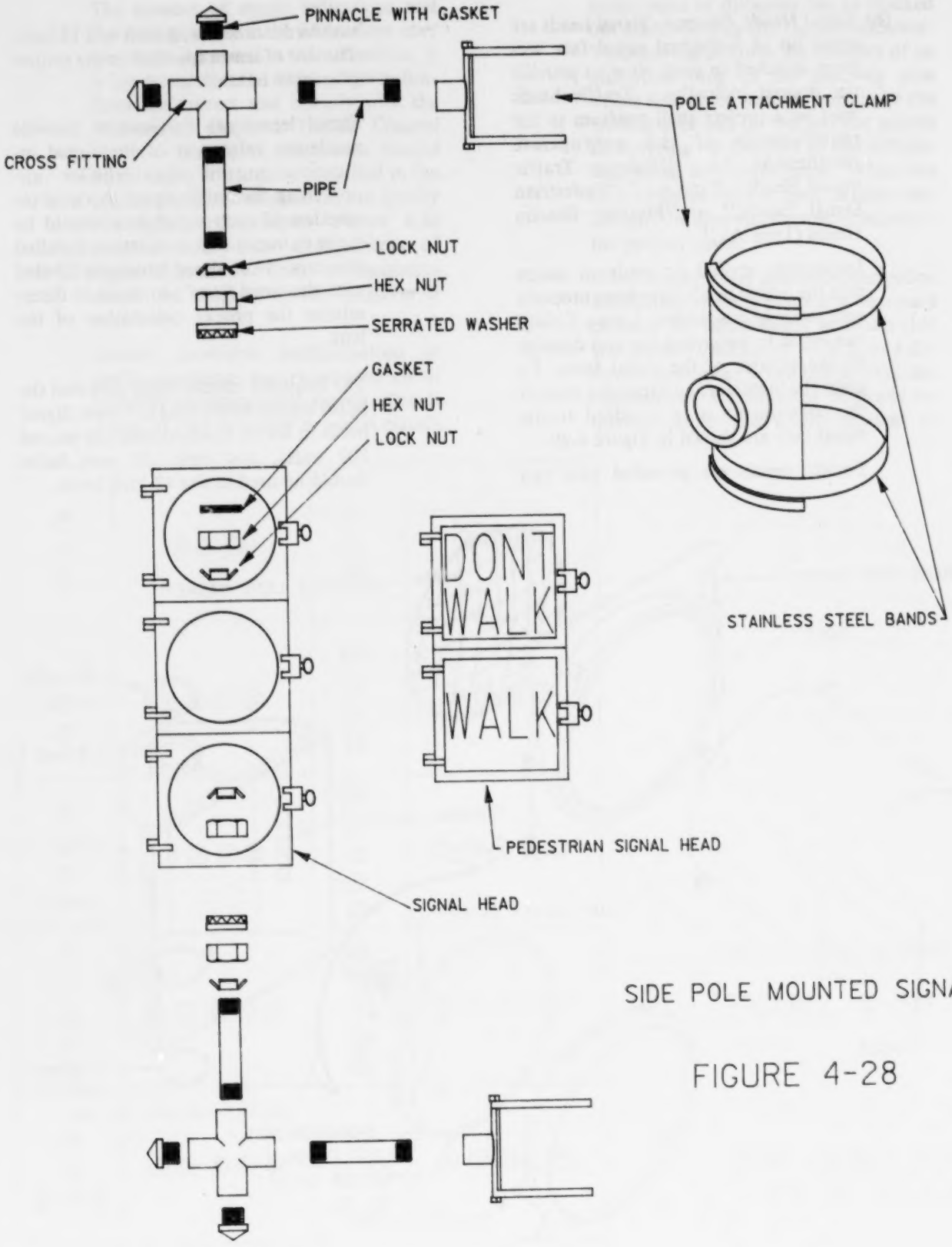

1½" PIPE BRACKET (SUPPLIER FURNISHED)
½" U-BOLTS WITH HEX NUTS AND FLAT WASHERS
MAST ARM
MOUNTING PLATE
½" THICK MOUNTING PLATE
SLOTS TO PERMIT VERTICAL ADJUSTMENT OF 1½" PIPE BRACKET

FIGURE 4-27



SIDE POLE MOUNTED SIGNAL

FIGURE 4-28

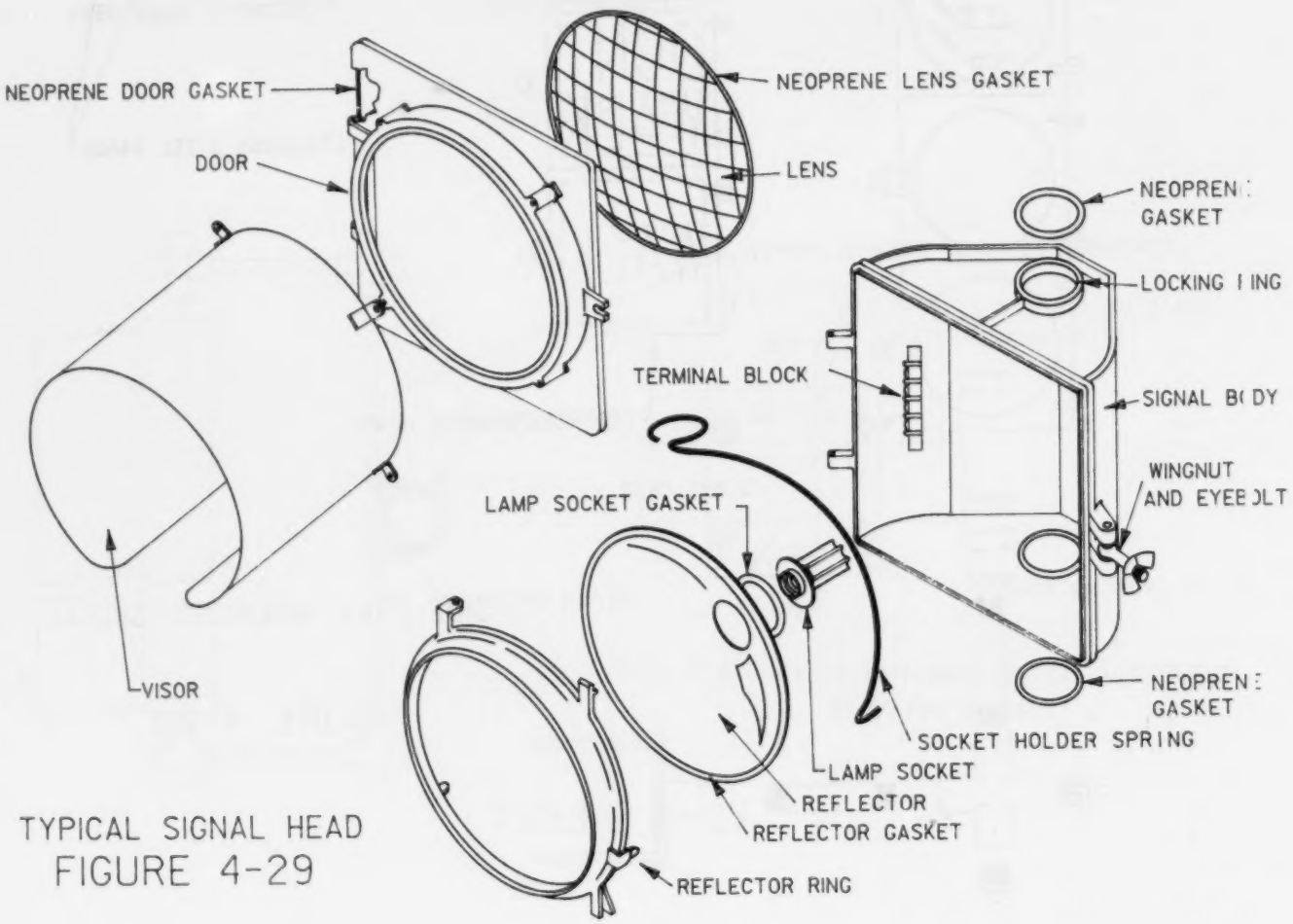
(h) *Signal Heads, General* - Signal heads are made up of individual signal face sections attached to each other to provide the desired indications. Traffic heads used on a project shall conform to the requirements of the appropriate specification, i.e., "Highway Traffic Signal Heads - Type A, " "Pedestrian Signal Heads," or "Flashing Beacon Heads (Type A)."

Inspections should be made to insure that the traffic heads have been properly and securely assembled. Loose fittings can result in water leakage and damage on the interior of the signal faces. To assist the inspector, an expanded view of the components of a standard traffic signal face are shown in Figure 4-29.

Traffic signals are provided with two standard size lenses, 8-inch and 12-inch. The size of lenses specified in the project plans will be used.

Signal lenses are designed to provide maximum refraction of the signal indication toward the vehicles approaching the traffic signal. A visual inspection of each signal face should be made to insure that each lens is installed properly. Most signal lenses are labeled with the word "top" to assist in determining the proper orientation of the lens.

The Inspector should make sure that the bulbs are the clear, long life type. Signal bulbs in 8-inch heads should not exceed 100 watts, and only 150 watt bulbs should be used in the 12-inch heads.

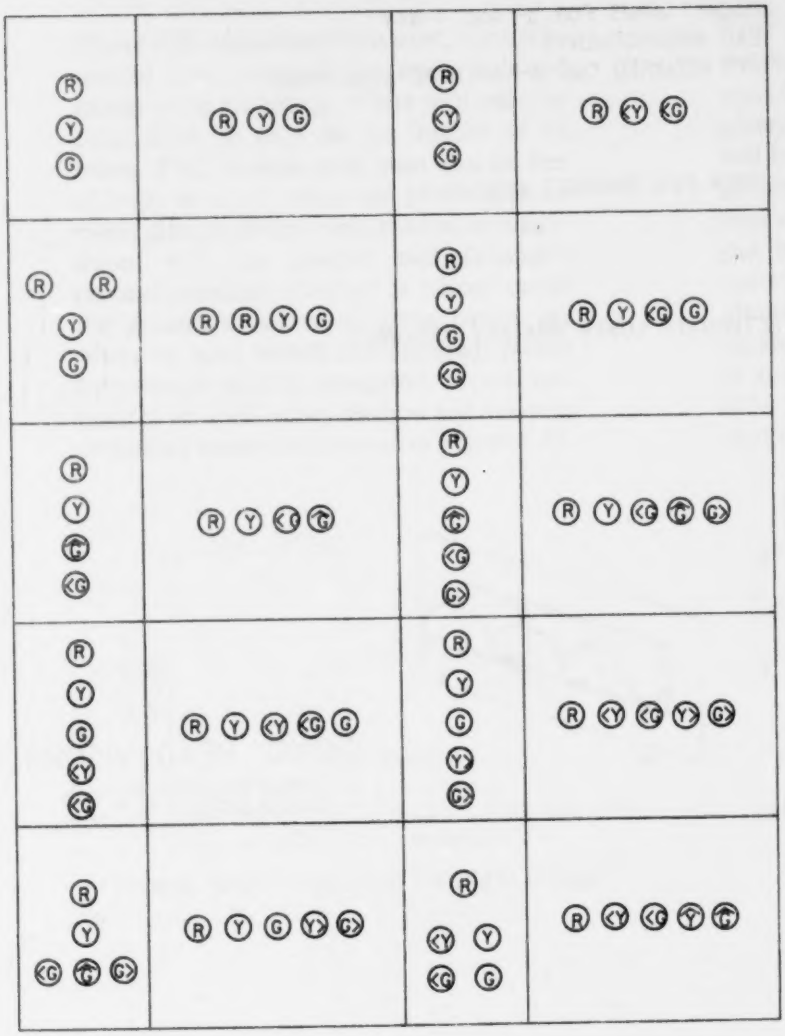


TYPICAL SIGNAL HEAD
FIGURE 4-29

The number of signal indications and the arrangement of the indications may vary from intersection to intersection. It is important that the order of the indications are correct and comply with the *Manual of Uniform Traffic Control Devices*. The signal indications should be arranged in the order specified in the project plans. If the plans do not specify the signal arrangements, Figure 4-30 provides acceptable arrangements of signal indications. These arrangements should be checked by the Engineer if necessary.

Certain geometric configurations or traffic conditions may require the use of optically programmable signals. This is a special type of signal in which certain areas, lanes or distances can be blacked out from viewing the signal indication. This type signal limits the visibility of an indication only to the roadway area where it must be seen. A portion of the viewing area can be blacked out merely by covering up the part of the diffuser where that area is projected. When this type of signal head is used, it must conform to the appropriate specifications in the project plans.

When a diagonally spanned intersection installation is being made it is necessary to hang the signal heads as a unit that will provide indications for 2, 3, or 4 different directions. When this is done, the signal heads are mounted vertically requiring upper and lower brackets to



SIGNAL INDICATIONS

FIGURE 4-30

keep the head aligned and to allow for secure positioning of the heads. Figure 4-31 illustrates a typical upper and lower bracket assembly. The heads and hanger brackets are attached to these brackets the same way as previously illustrated in Figures 4-21 and 4-28.

Visors are used on signal faces to aid in directing the signal beam specifically to approaching traffic, as well as to reduce "sun phatom" or reflections resulting from sunlight or external light entering the lens. The inside surface of all visors should be a flat black finish. In some instances a backplate may be required on the signal heads to provide better visibility of the signal indications. Backplates are usually a thin strip of material installed around the signal head that extends outward from the face of the indications. Backplates should be a flat black color on the signal indication side of the signal head. Figure 4-32 shows the backplate and the most commonly used visors.

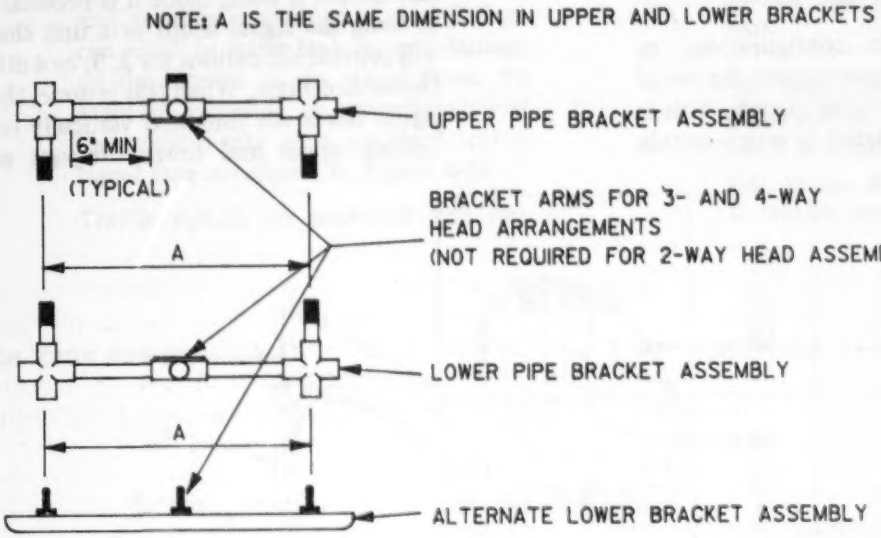
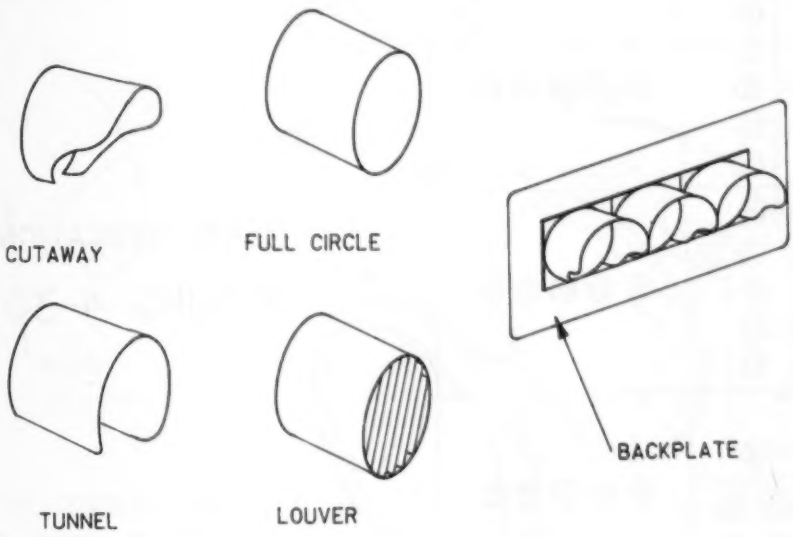


FIGURE 4-31



SIGNAL HEAD VISORS
FIGURE 4-32

4.3 Conduit and Pull Boxes

Most signal installations require the placing of electrical wiring in the ground. When this is done, underground conduit is used to protect, maintain, and replace the wiring when necessary. Pull boxes are used at the terminal points of conduit or at intermediate locations to provide access to the electrical wiring. Conduit shall be of the type and size specified in the plans and is usually either a rigid metal or a rigid PVC conduit.

Conduit terminating in post and pedestal bases must extend vertically about 2 inches above the foundation. Field bending of metal conduit must have a minimum radius of 12 times the diameter of the conduit.

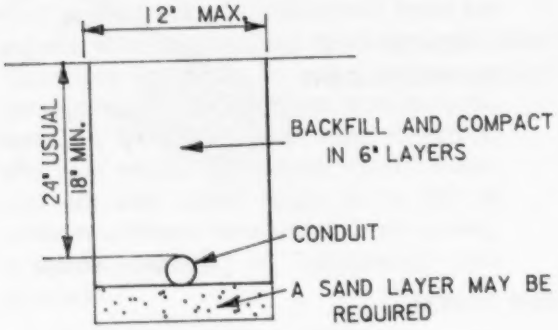
Where rigid metal conduit is used, it must be reamed and threaded on each end and joined using a bushing. White lead paint or equal must be used on the threads of all joints. PVC conduit ends must also be free of burrs or sharp edges and joints must be made using a solvent-weld method in accordance with the conduit manufacturer's recommendation. Conduit is placed under the ground in either an open trench or, where an open trench is prohibited, placed by boring or jacking a mandrel. Typical sections of an open trench method and a boring or jacking method are shown in Figure 4-33.

The jacking or boring method used must not interfere with the operation of the street, highway, or facility and must not weaken or damage any embankment, structure, or pavement. Open cuts in the roadway pavement are not allowed unless approved by the Project Engineer. During jacking and boring operations, the Inspector should make sure that the overbore tolerance does not exceed the plan specifications.

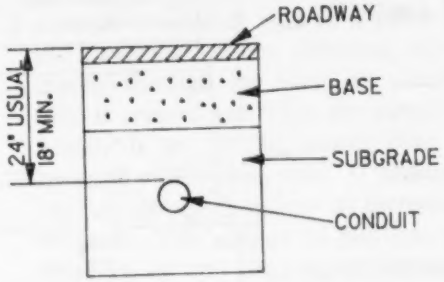
A typical conduit run underneath a roadway is shown in Figure 4-34.

All excavation required for placing conduit must be replaced and finished neatly to the grade line existing prior to the start of the excavation. Any concrete removed for bore pits or the placing of conduit should be replaced in a manner to blend with the existing concrete in place.

Pull boxes will be of the shape, size and type specified in the plans. Pull boxes must be placed so that the top surface of the pull box will be at the same elevation as the existing ground around the pull box to prevent mower damage. Materials used to fabricate pull boxes may vary and if the plans do not specify a specific type of pull box, the type should be approved by the Project Engineer. A typical pull box and installation is shown in Figure 4-35. Shown in Figure 4-36 is a picture of a completely installed pull box, conduit and wiring.

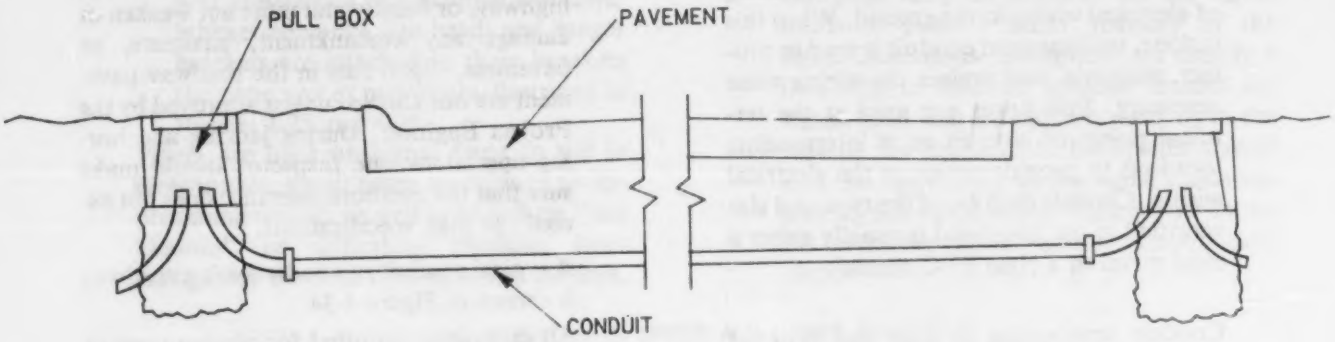


TYPICAL OPEN TRENCH SECTION

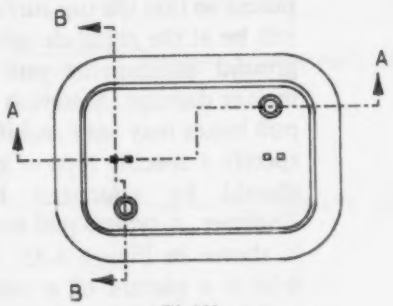


TYPICAL SECTION THROUGH ROADWAY (BORED SECTION)

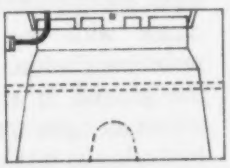
FIGURE 4-33



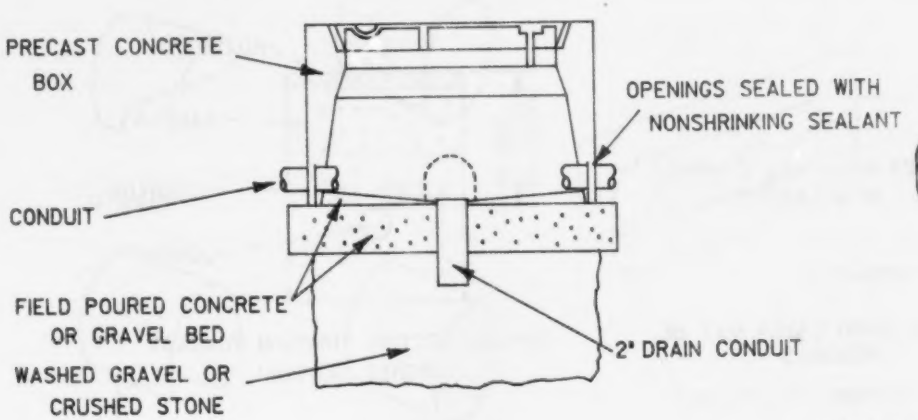
TYPICAL SECTION OF CONDUIT RUN
FIGURE 4-34



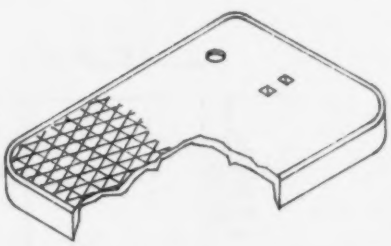
PLAN



SECTION B-B

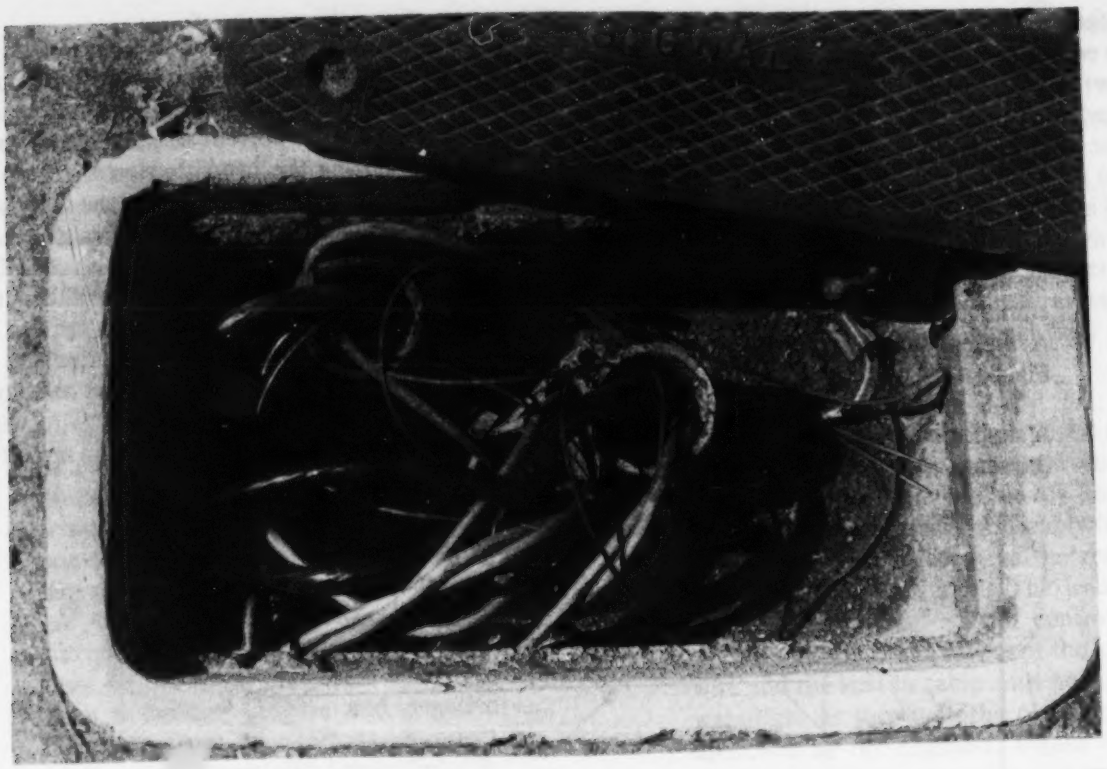


SECTION A-A



CAST IRON COVER

TYPICAL PULL BOX
FIGURE 4-35



INSTALLED PULL BOX
FIGURE 4-36

4.4 Loops and Other Detectors

Traffic actuated signal equipment uses detectors for telling the controller that vehicles, pedestrians, or priority vehicles such as fire trucks, ambulances or buses are present at or approaching the intersection. Detections are made by using inductance loops, pressure sensitive pads, push buttons, magnetic detectors, radar, sonic detectors, and light emission detectors. Traffic detectors are used either singly or in sets to measure different variables; such as volume, pressure, speed, or occupancy (see glossary).

Detectors operate on one of two principles, either by using pressure to cause contacts on a switch to close, or by using a change in energy caused by the presence of a vehicle.

(a) *Loop Detectors* - The loop detector is presently the most commonly used vehicle detector for traffic signals. A loop is formed by placing one or more turns of a single conductor wire in a pattern in the pavement. When electrical current travels through the wire, an electrical field is created and when the metal of a vehicle is present or passes over the loop, the electrical field is disrupted causing the 'inductance' to increase or decrease. This change in inductance is detected by the loop amplifier which registers that a vehicle has passed.

The sizes and shapes of loops vary, depending on the function they are designed to serve. Loops must be installed as specified in the plans so that the desired operation can be obtained.

The installation of loops requires the cutting of the pavement with a pavement saw, placing a specific number of turns of wire in the saw cut, and sealing the pavement cut with an appropriate sealing compound. Saw cuts should be made at the depth shown in the plans and all corners of the loop layout should be sawed at a 45 degree angle to eliminate sharp bends in the loop wire. A typical saw cut pattern is shown in Figure 4-37.

A single conductor loop wire is placed in the saw cut for the specified number of turns required for that particular loop. Figure 4-38 illustrates a typical loop having two turns of wire. Care must be taken to prevent scraping, breaking or cutting the insulation on the loop wire when placing the wire in the saw cuts. A damaged wire will result in a shorted circuit and a loop detector which will not work. After the wire is in place, an approved sealant should be applied into the saw cuts, making sure that the loop wires are inside the saw cuts and not exposed to traffic. Exposed wire will be worn by traffic and result in a malfunction of the detector.

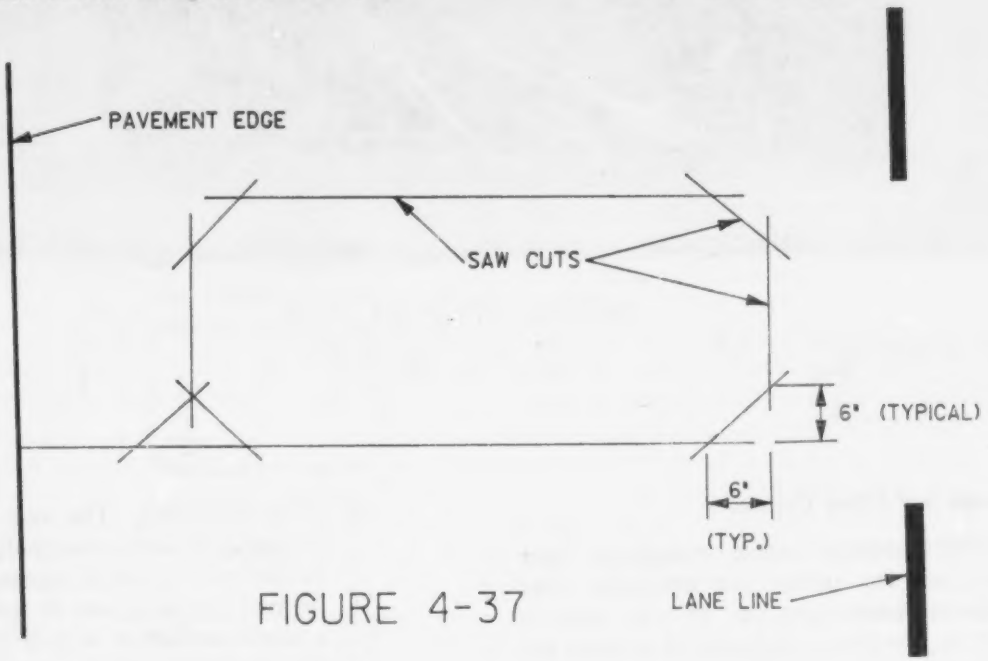


FIGURE 4-37

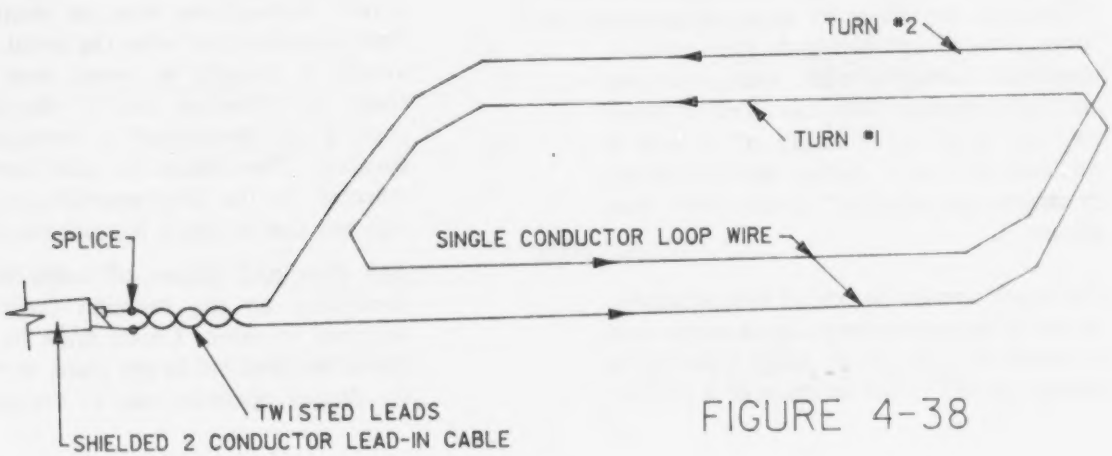


FIGURE 4-38

Placement of inductive loops in the travel lanes where two or more adjacent lanes have separate loops is very important. Placing the edge of the loop too close to the adjacent lane can result in the cars in the adjacent lane being detected. This condition causes false calls to the controller and results in inefficient operation of the signals. Therefore, the loop's edge should be placed no closer than 2 feet to the lane line separating adjacent lanes.

As current passes through the loop wire, an electric field is created. This field is much stronger near the wire than away from it. A "contour map" of this field could be drawn to show the relative strength of the electric field. These lines are called lines of "flux". The difference between flux lines and contour lines on a map is that these flux lines have a definite positive and negative direction. This direction is dependent solely on the direction of the current in the loop wire. As metal passes within this electric field, as in a car moving over the loop, these lines of flux are upset which causes the voltage in the loop to change slightly. These changes are detected in the loop amplifier. Consequently, the wire leads between the loop and the amplifier must be protected from sensing moving metal nearby. Since the lead-in wire has current moving in both directions (out to and back from the loop) the lines of flux will be in opposite directions. The closer the two wires are to each other, the more these flux lines cancel each other. Ideally, one wire should surround the other wire (as in shielded coaxial cable) but this can be simulated by twisting the lead in wires together. For this reason, the Inspector should make sure the lead-in wires have at least three full twists in each foot of cable (see Fig. 4-39).

The loop wires must not be spliced except where they are connected to a shielded lead-in cable outside the limits of the roadway surface, preferably in a pull-box located adjacent to the roadway at the loop location. The lead-in wire from the loop to the controller must be shielded. The splices of the loop wire and the lead-in cable must be made watertight as shown in the plans or as approved by the Engineer. Figure 4-40 illustrates a typical plan view and cross-section of a loop installation. Figure 4-41 consists of pictures of the various stages of installing loop detectors.

Loop detectors tend to deteriorate faster than any other part of a signal. The Inspector should take special care to make sure sharp rocks that could damage insulation are removed from the saw cut.

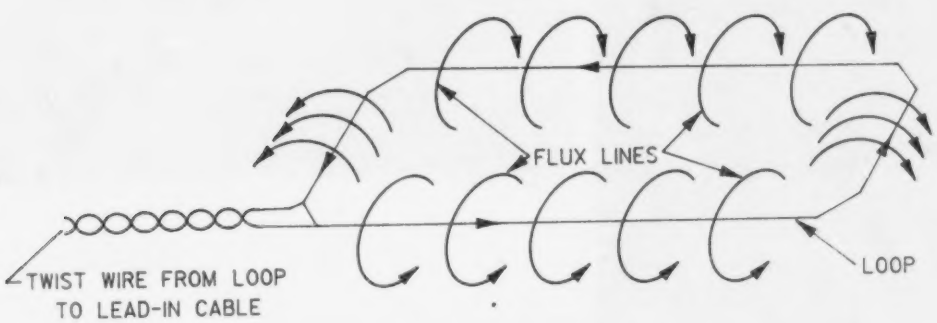
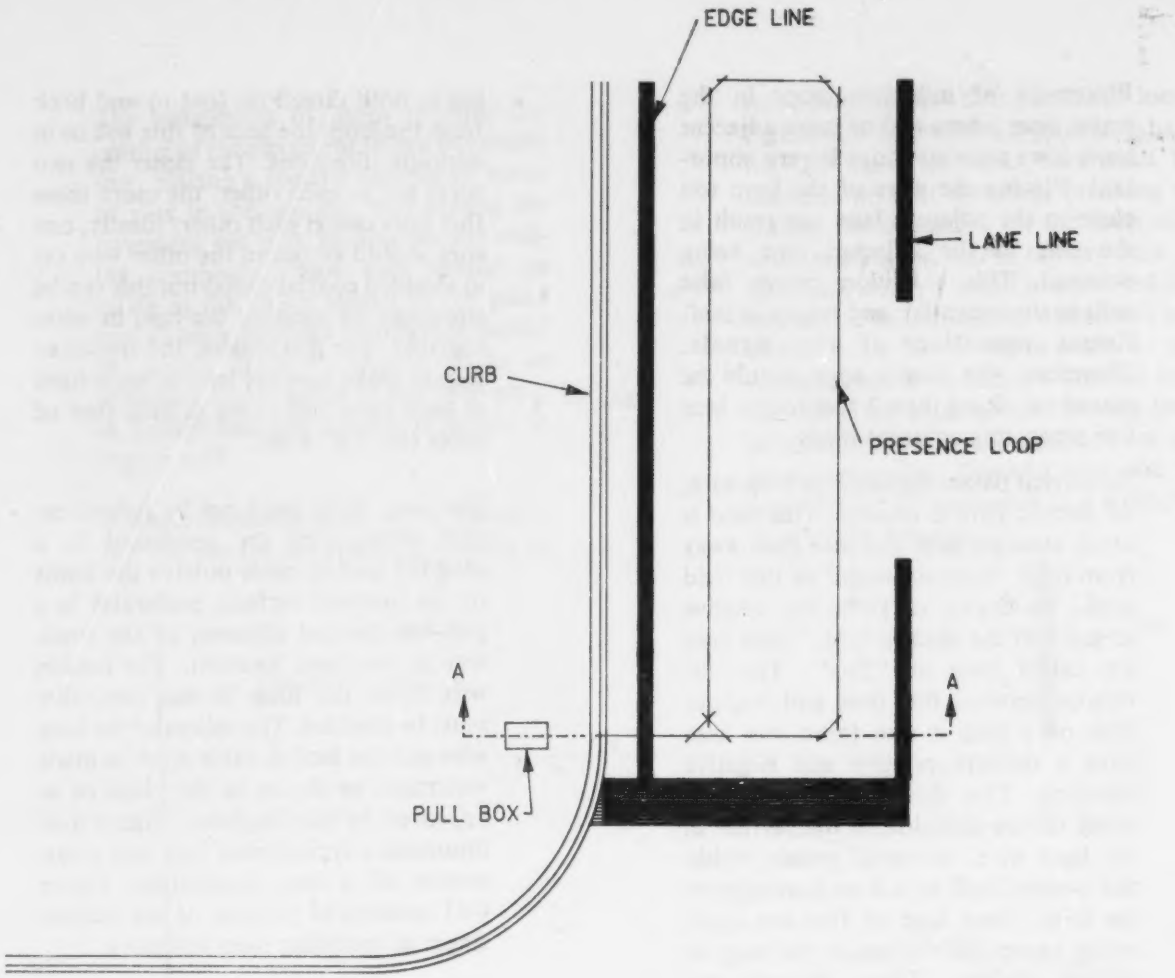
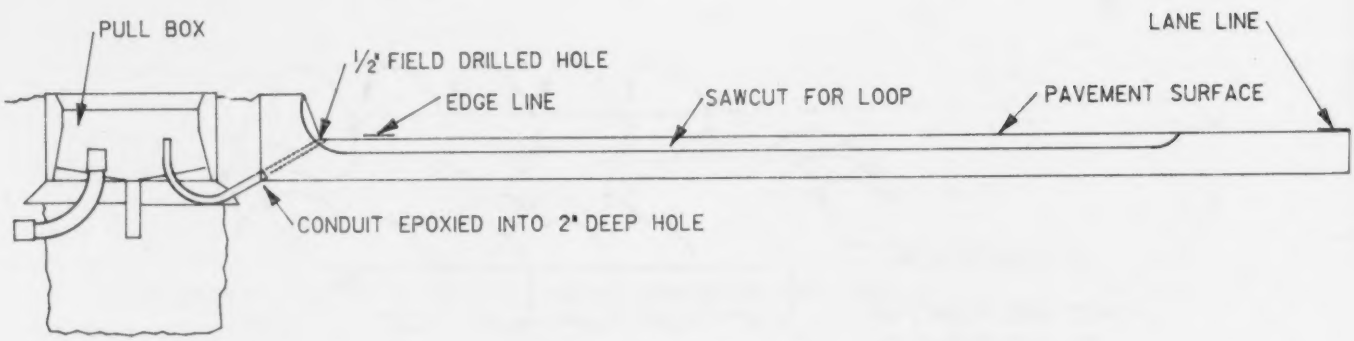


FIGURE 4-39



PLAN VIEW

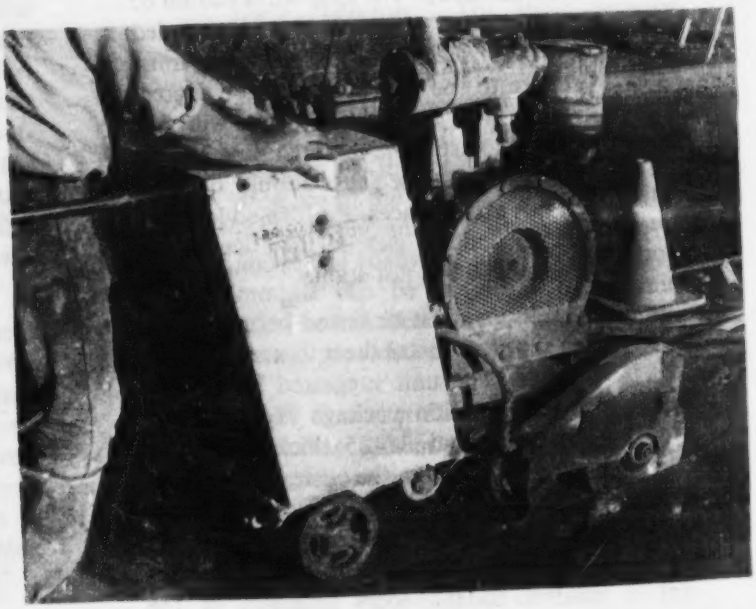


SECTION A-A (TYPICAL)

FIGURE 4-40

STAKING A LOOP LAYOUT

SAWING THE LOOP



COMPLETED SAWCUT

CLEANING THE SAWCUT

FIGURE 4-41

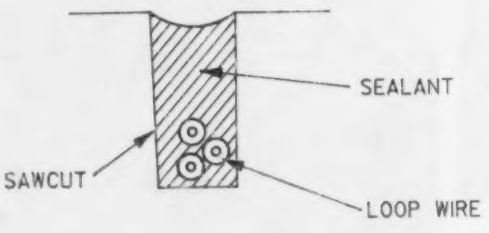
Special slack at joints or cracks (see Fig. 4-42) will minimize future insulation breaks.

The loop sealant is an important part in a durable loop. The loop wires should be encapsulated (completely surrounded by) the sealant. The material must adhere to the pavement surface. Epoxy works well on concrete but will not adhere to asphaltic material, and special non-hardening sealants should be used on hot mix surfaces. Preformed loops in plastic conduit can be used where the road surface is not stable.

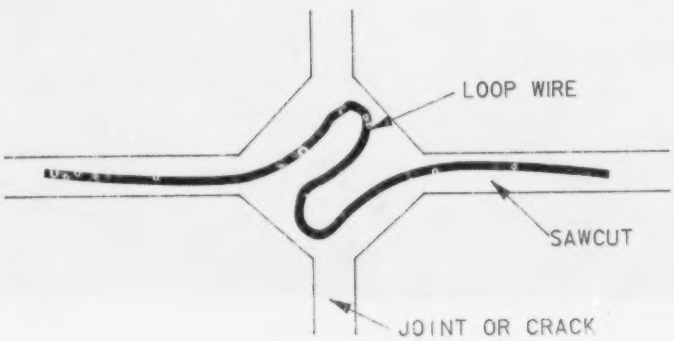
The loops must be tested before acceptance with a metal sheet that simulates a vehicle. The unit suggested by FHWA Implementation package 76-2 is a 30" flat octagonal 3/32" thick aluminum with a 18" hole in the center. Sometimes after an overlay it is difficult to locate the loop in the pavement. The audio output of a transistor radio can be connected to the loop terminal in the cabinet. Using a phone pick up unit and an ear speaker the Inspector can easily trace the loop wire out.

(b) *Pressure Sensitive Detectors* - Pressure sensitive detectors operate on the principle that when a vehicle crosses the pad, the weight of the vehicle causes the closure of contact plates which transmit a signal to the signal contoller. Pressure type detectors normally are 6 to 8 feet in length. To install these pressure detectors requires digging a trench in the roadway and building a foundation to support the detector pad assembly. The foundation will be built as shown in the plans. Care must be taken to install the pressure pad assembly in a manner where the top of the frame is finished to the same grade as the roadway surface. Conduit should also be placed in the roadway from the detector assembly to the edge of the pavement, or to a pull box, in order that the necessary wiring can be placed. Pressure detectors shall conform to the specification "Pressure-Sensitive Vehicle Detectors."

(c) *Push Buttons* - At locations where pedestrians cross frequently, push buttons may be installed for certain types of traffic control signals. The push button provides a means for the pedestrian to place a call to the controller for a change in the signal right-of-way or to call in a pedestrian phase when pedestrian signal indications are provided. The push button assembly consists of contacts enclosed in a housing that close when the



SECTION OF LOOP
INSTALLED IN SAWCUT



PLAN VIEW AT A JOINT

FIGURE 4-42

button is pushed, sending a detection to the controller.

Push buttons should be installed at the locations and heights shown in the plans. If a height is not shown in the plans, the push button assembly should be mounted approximately 3½ to 4 feet above the sidewalk or the groundline at the mounting location. The push buttons shall meet the requirements of the specification item "Pedestrian Push Buttons." Each push button installed should be supplemented by a sign giving pedestrians instructions..

(d) *Magnetic Detectors* - The magnetic detector is based on the flux lines from the earth's magnetic field. When a metal object, such as a car, passes over or near this detector, the flux lines are moved. This movement of the flux lines causes a voltage change which serves as a message to the controller that a vehicle has been detected.

The magnetic detector is cylindrical in shape. The cylindrical detector portion is placed under the roadway surface perpendicular to the roadway. Installation must be in accordance with details provided in the plans.

Another form of the magnetic detector is a "magnetometer." The magnetometer detector is a small cylinder which is placed in a small core hole in the roadway and sealed with an approved sealing compound. The magnetometer detector must comply with the specification "Magnetometer Type Vehicle Detector."

(e) *Radar Detectors* - The basic radar type detectors operate by sending microwave beams downward from an overhead mount position. The passage of a vehicle through these beams causes them to be reflected back to a sensing unit which denotes a vehicle detection. The radar detector is usually installed overhead to obtain the most accurate detections. The installation must be done in accordance with details provided in the plans. The use of radar detectors requires a Federal Communications Commission (FCC) license.

(f) *Sonic Detectors* - The sonic detector operates on the same principle as the radar detector. The sonic detector sends a beam of ultrasonic energy which is reflected back by a vehicle, sending an impulse to the controller noting the presence of the vehicle. The sonic detector sending unit is usually mounted above the roadway; however, side pole mounts can be installed. These units must be installed in accordance with the details provided in the plans.

(g) *Light Emission Detectors* - Light emission detectors are sometimes used for assigning right of way at a signal location to priority vehicles. Priority vehicles may be buses, police cars, fire trucks, and ambulances, etc. The light emission devices must conform to the plan specifications and details. These detectors consist of a high-intensity light emitter mounted on the priority vehicle and a receiver unit at the signal. When the light beam is detected by the receiver, it relays this detection to a phase selector for assignment of right-of-way through the signalized intersection. Light emission detectors must be installed in accordance with details provided in the plans.

4.5 Wiring and Communication Cable

All wiring must be durable and of sufficient size to carry the electrical load without overheating. Specifications for signal wirng prepared by IMSA are normally used, and cable is dated and symbolized inside the jacket by the manufacturer. Certifications by testing labs must agree with the date and manufacturer. The national electric code defines wire size and maximum conductors in conduit for different loads and uses. The latest edition of the code should be used as a reference for good electrical practice.

Loop detectors and any applications that require repeated flexing should use stranded conductors. The terminals for stranded conductors require a special tool and care must be taken to assure that the terminals are tight on the conductor. Solid conductors can readily be formed into terminal units and a visual check is all that is required to see if a good terminal has been made. Where stranded conductors are joined to solid conductors, a soldered joint is preferred.

The industry standard for wire gauge size is A.W.G. as outlined in the national electric code. Traffic signal cable will usually have 5, 7 or 9 conductors. Communication cable may have up to 50 pairs. A visual check of the size, type and number of conductors should be made when materials arrive on the job. In one instance signal cable was received on a job having 7 conductors at one end and only 6 conductors at the other end. A wire gauge template is useful in checking conductor size and insulation thickness.

Signal wiring should be done with maintenance in mind. The signals will be subjected to damage from high loads, ice, rain and normal deterioration due to age, vibration and corrosive atmosphere. Each terminal connection introduced into the circuit provides another place where loose connections may develop. The Inspector should be alert for wire splices in hidden areas such as inside conduit or poles. These splices should not be allowed. Pulling wire into conduit should be done carefully to avoid damage to the insulation. Signal cable with an external jacket has reduced this problem. Forcing the wire will cause damage to the insulator which may become a short later.

Every effort should be made to keep water out of the signal equipment. Wiring should be shaped to provide drip loops at signal heads and pole entry points and sealing grommets should be used. Moisture that enters the system can cause the new solid state conflict monitors to force the controllers to go into flashing operaton. Moisture will also cause deterioration of the insulation; and at terminal points and splices, moisture can cause corrosion that may build up a "hot spot."

One way to check for minor electrical leaks is to "meg" the circuit. A 500 volt dc voltage is applied to an open wiring circuit and the resistance to ground is measured. This resistance should exceed one megohm (see RID (4)-82).

The megger circuit test should be made on a random basis unless defective lines are found. The loop should be megged in all cases and recorded.

On computer signal systems, communication cable quality checks should be made using a signal generator and oscilliscope. If the Inspector is not trained to check this type of cable, D-18T should be contacted for assistance. All cable pairs should be labeled with bad pairs noted, and a written field test report should be provided for documentation. Coaxial cable requires special testing procedures and D-18T should always be contacted for assistance. Signal clarity required by computer or multiplex equipment must be maintained, which will always require a high degree of care by the Contractor in installation details. Lightening protection should be provided for all wiring and communication circuits.

4.6 Controllers

The controller is the electronic device which switches the light circuits. Vehicle detection, coordination, preemption, and other equipment supports the controller function and will also be in the Controller Cabinet. The controller should be located so that the technician will be able to view the intersection as clearly as possible. The controller should also be protected as much as possible from out of control vehicles and other incidents. The inspector should be aware of possible flooding by high water in certain areas and be aware of the tremendous hazard that would result from the technician standing in water while working on the controller. Controllers should not be located near overhead edges or joints on bridges that will drain water onto the equipment.

An inspection of the controller by the Materials and Tests Division in their environmental chamber is sometimes required. D-9 may test one of each type on jobs with multiple controllers. The specifications of the controller should be reviewed line by line to make sure that all items have been provided for. A light board with full 100 watt lamps should be used to test the sequence of the controller to make sure it will provide the features required in the plans and specifications. Pretimed controllers should be set and operated in the shop to make sure the dial key contacts are properly adjusted for uniform and proper operation.

Simple yet adequate instructions along with complete schematic and wiring diagrams should be provided as indicated in the plans and specifications.

With the use of additional accessory equipment the cabinet may become crowded. There should be ample room for heat dissipation and the arrangement should be designed so that the equipment can be maintained easily. Packing the accessories into all available spaces may appear to be economical but will lead to maintenance problems later and should be avoided if at all possible. The cabinet ventilation system should be checked to assure that driving rains will not result in water getting on the control equipment.

The accessory equipment should be tested in the field to determine if it operates properly. A check should be made of conflict monitors to make sure they will cause the controller to go into flashing operation. Field testing of the conflict monitor must be made with a shorting wire after the entire installation has been placed in operation. The railroad preemption equipment must function as specified and should be designed so that it may be easily removed for maintenance. Time base coordinator units should be checked against the specifications and should be operated in the shop for a period of 4 weeks to assure that it will maintain proper time base coordination. Lightening protection equipment and line filters are a must for all equipment, both in low and high voltage circuits. The Inspector must be sure that all circuits are equipped with lightening protection units. If in doubt, he should contact D-18T for assistance.

In the installation of the signal controllers all terminals should be properly labeled and a drawing should be provided on the cabinet door indicating the phase sequence assignment numbers along with detector assignment numbers.

4.7 Digital Computer Systems

There are two basic types of Computer Traffic Signal Systems currently being installed, (1) vendor traffic systems which are typically large, Central Business District (CBD) or network type systems where the Contractor furnishes all computer hardware and software, and (2) departmental traffic systems or FACTS (Flexible Advanced Computer Traffic Signal) Systems where the Department furnishes and installs the computer system.

The plans and specifications for Department installed systems have been designed such that the highway contractor sees the project as one which involves the routine interconnection of traffic signals (signal installation, communication cable installation, etc.) and minimizes his involvement with the computer functions. Therefore, since the computer systems and communication interface equipment are furnished and installed by the Department (State Force Account Work), no inspection or testing of computer equipment is required by Department inspectors. The only requirement of the District is to provide personnel to assist in the actual field installation of the communication interface equipment.

The vendor supplied computer system consists of the digital computer complete with all required peripheral equipment and any required special options or features of the computer. The peripheral equipment includes all standard input/output type devices such as the teleprinter, card reader,

line printer, CRT terminal, time-of-day clock, magnetic disc storage device, and communications interfaces. All peripherals in stand alone locations should have lightening protection.

The vendor traffic system requires extensive inspection and testing of the computer system and must include, as a minimum, both the verification of all required physical features and the operational test of each item of equipment as follows.

(a) Verify that lamps or other types of displays which give the operational status of the computer, such as power on, run, halt, etc., are supplied and are visible from the front of the computer.

(b) If the computer contains the powerfail/autorestart feature, verify that it is working correctly by turning the power (AC voltage) to the entire computer system off and back on. The computer should restart automatically without operator intervention.

Peripheral equipment should meet all physical requirements as given in the specifications, such as printing speeds, number of characters displayed, number of disk units, number of cards read per minute, etc. All physical features and operational characteristics should be verified by observation.

Operational tests consist of running computer programs to test all computer components and all peripheral equipment. These programs are generally referred to as test programs or diagnostic programs. There should be a specific test program supplied for each peripheral device and for the computer's logic and memory, plus any other test programs defined in the specifications.

Documentation must be supplied for all components of the computer system and as a minimum will consist of operator's and maintenance manuals and electronic schematics for all equipment, plus any other documentation required by the specifications.

The specifications for the vendor supplied computer system will generally be very detailed and should serve as a concise guide for the inspection and testing of the equipment. In addition, specific instructions for operational features, tests, and documentation will be detailed explicitly in the specifications. Any special expertise required for the inspection of this type of system will be furnished by D-18T and D-19. If the Inspector lacks the expertise to perform these tests, he should contact D-18T for assistance.

4.8 Illumination on Signal Poles

The signal plans may specify that illumination be installed at certain intersections to provide better visibility during dark periods. This requires that the luminaire heads and arms be attached to the signal poles. The luminaires shall be installed at the locations shown in the plans.

The most commonly used illumination falls within one of two categories, mercury vapor or sodium vapor. The power of the luminaires mounted on signal poles may vary from as low as 90 watts for low pressure sodium to 400 watts for mercury vapor. The type of illumination and wattage required shall be that specified in the project plans.

The four basic components of a luminaire are the luminaire housing, lamp, photoelectric cell and the ballast. The luminaire housing is that portion of the reflector, lamp socket and the glass lens (refractors). It may also serve to house the photoelectric cell and ballast. The glass refractors will be hinged to the housing to allow servicing the luminaire and changing the lamp.

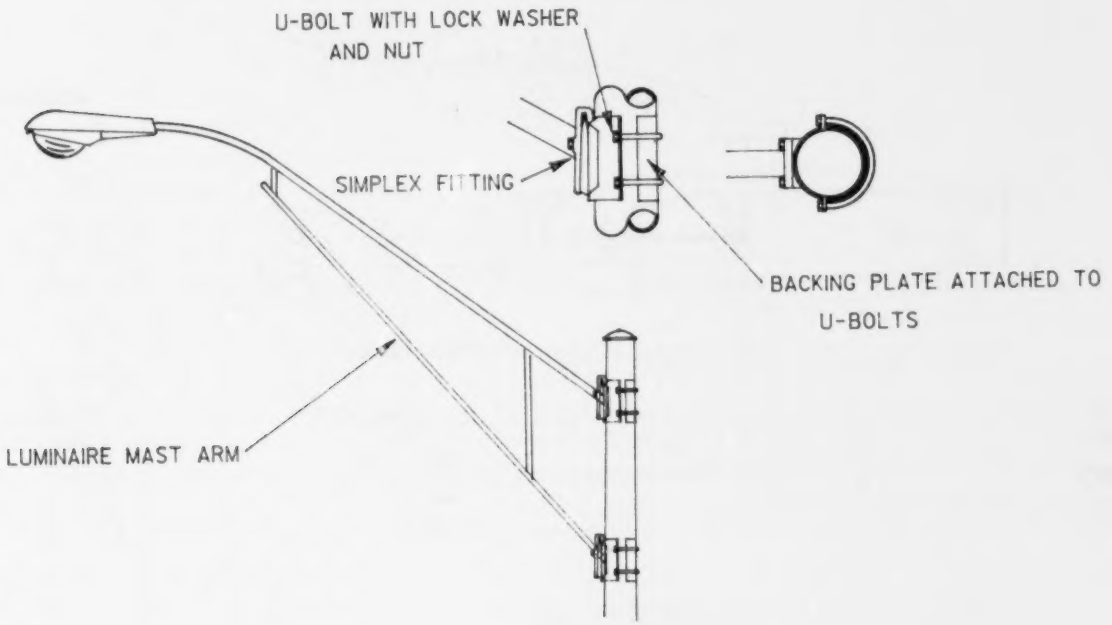
The photoelectric cell is used to automatically turn the luminaire on and off in darkness or light. The photoelectric cell is wired between the power supply and the ballast. It operates on the principle that as the intensity of light decreases or darkness sets in, the resistance of the cell increases, causing the current flow to decrease to a

point which is not sufficient to hold a contact switch open. When this happens, the switch is closed and the ballast and lamp are supplied current. The reverse process takes place in the morning or as the light intensity increases. The photoelectric cell is located on top of the luminaire housing for most types of luminaires furnished for signal projects. However, the photoelectric cell may be mounted independently of the luminaire housing.

A ballast is necessary for luminaires to operate properly. Basically, the ballast serves three functions: (1) starts the lamp, (2) keeps the lamp operating within its design parameter, and (3) adapts the lamp to the line voltage available. Luminaires may be wired for 120 volts since this is normally the power supplied to the signal controller.

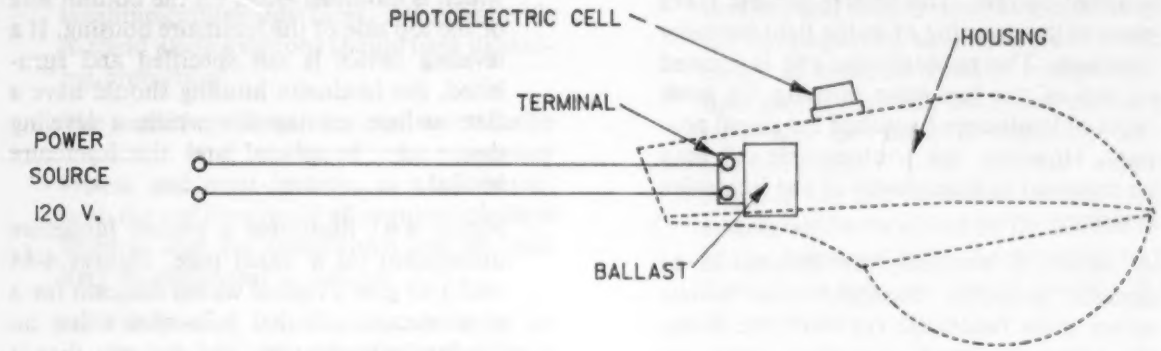
The Inspector should make sure that the luminaire is level when installed. This is accomplished by utilizing the leveling device which is mounted either on the bottom side or the top side of the luminaire housing. If a leveling device is not specified and furnished, the luminaire housing should have a flat surface on top on which a leveling device can be placed and the luminaire leveled.

Figure 4-43 illustrates a typical luminaire installation on a signal pole. Figures 4-44 and 4-45 give a typical wiring diagram for a photoelectric cell that is located either on the luminaire housing and for one that is located independently of the luminaire housing. Figure 4-46 illustrates a typical luminaire housing assembly and Figure 4-47 illustrates the shapes of the different types of lamps normally used for illumination.



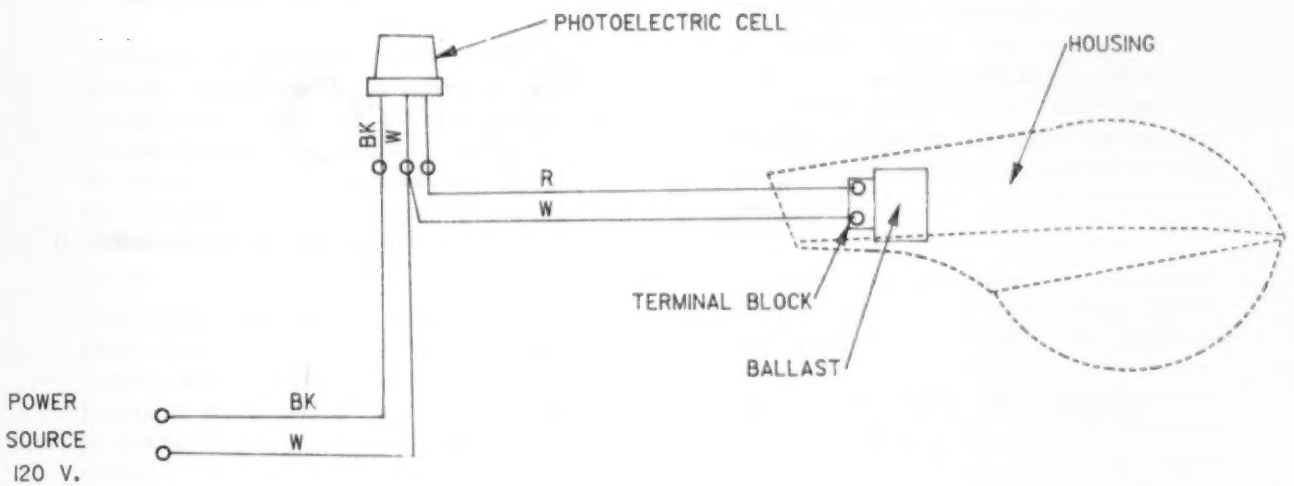
LUMINAIRE MAST ARM MOUNTING DETAILS

FIGURE 4-43



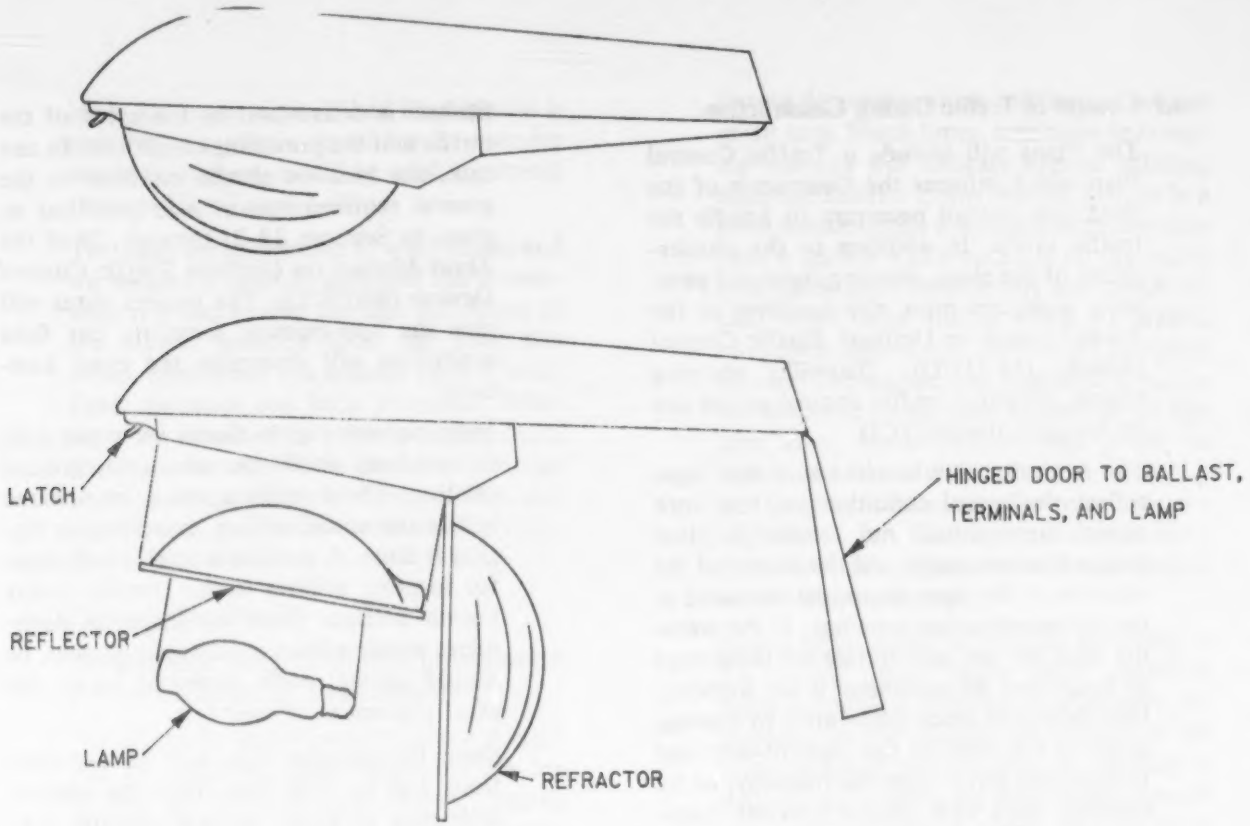
TYPICAL WIRING DIAGRAM FOR A PHOTOELECTRIC CELL MOUNTED ON THE LUMINAIRE HOUSING

FIGURE 4-44



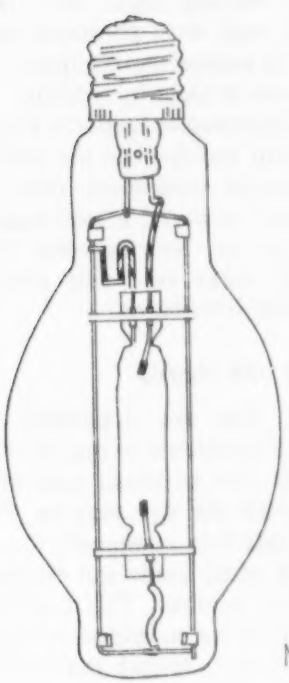
TYPICAL WIRING DIAGRAM FOR INDEPENDENTLY MOUNTED PHOTOELECTRIC CELL

FIGURE 4-45

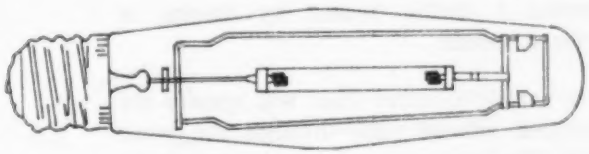


TYPICAL LUMINAIRE ASSEMBLY

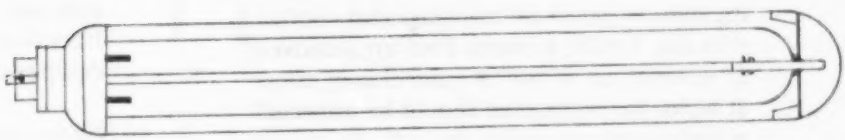
FIGURE 4-46



MERCURY VAPOR LAMP



HIGH PRESSURE SODIUM LAMP



LOW PRESSURE SODIUM LAMP

FIGURE 4-47

4.9 Control of Traffic During Construction

The Plans will include a Traffic Control Plan which informs the Contractor of the minimum control necessary to handle the traffic safely. In addition to the requirements of the plans, warning signs and pavement markings must also conform to the Texas Manual on Uniform Traffic Control Devices (MUTCD). Diagrams showing typical minimum traffic control setups can be found in the MUTCD.

The Inspector should make sure that signs reflect the actual conditions in the work zones. Signs should not remain in place longer than necessary and the timing of the erection of the signs should be discussed at the pre-construction meetings. If the warning signs are not appropriate for those days or hours that the contractor is not working, they should be made inoperative by moving them to the edge of the right-of-way and facing them away from the roadway, or by covering them with opaque material. Leaving construction warning signs in place when they are not needed has at least three adverse effects: (1) motorists ignore the signs, (2) respect for all warning signs is lessened, and (3) Law abiding motorists become a traffic hazard by driving at reduced speeds.

The Traffic Control Plan will specify the intended vehicle path through the work zone. The Engineer must approve any deviation from the plans before it is attempted. The Inspector should make sure that existing signs or pavement markings that conflict with the Traffic Control Plan are removed or covered up. If traffic control is in effect at night, the work zone should be inspected at night to insure proper sign reflectivity and also to insure that conflicting pavement markings that have been covered up do not show through. Abbreviated markings should not be used for more than two weeks.

4.10 Advance Warning Signs With Flashers

The location of advance warning signs with flashers is determined by the speed of the traffic and the prevailing conditions. In any case, the location should conform to the general requirements of sign positions as given by Sections 2A-21 through -29 of the *Texas Manual on Uniform Traffic Control Devices* (MUTCD). The project plans will give the approximate locations but field conditions will determine the exact locations.

Most highway rights-of-way serve not only the roadway itself, but also underground utilities. These utilities must be located before any actual drilling, trenching, or digging is done. A good source of information for locating utilities is the District Utility Permit Section. Once the Inspector determines which utilities are actually present, he should contact each owner to locate the exact placement of their line.

Since the warning sign will be anywhere from 250 to 1500 feet from the hazard, driveways or other physical features may influence the location of the sign. The Inspector should be careful not to allow the sign to restrict sight distance for entering or exiting traffic.

Some advance warning signs will have special features, such as a photocell controlled dimmer to reduce the brightness of the flashing beacon at night by reducing the voltage supply. This feature keeps the bright warning light from washing out the text at night. Other special equipment such as railroad equipment contacts, special relays, magnetic contacts, etc. may be used. The Inspector should make sure that special equipment is properly installed.

4.11 Signs Associated with Signals

Normally signs that are applicable to specific signals are positioned as near to that signal as possible. For overhead span-wire or mast arm signals the sign may be well above the underside light commonly found on pole-mounted signal heads and external illumination will be required. This illumination may come from an incandescent light for small signs or 24- to 36-inch fluorescent

lights for larger signs. When illumination is mounted on plastic signal heads, oversize one-inch washers should be used to prevent tearouts (See Figure 4-48).

The signs are susceptible to wind forces and the Inspector must be sure that the connections are free so that the sign will return to the normal position after the wind dies down. High loads can damage signs if insuffient clearance has been provided. When signs are attached to a free-swinging head, the Inspector should be sure that the sign and signal are properly balanced and that wind forces do not cause the head to twist. (See Figure 4-49).

4.12 Construction Details

These details bring up specific points which are not discussed in detail elsewhere.

For all traffic signal projects, some digging will be required. Since many utilities are located on highway right-of-way, digging must be located carefully to avoid interference. The plans will show the approximate location of underground utilities, but the exact location must be determined in the field. Before digging begins, the Inspector should determine which utilities are present in the area. Many times, manholes or metering stations will indicate present utilities; also, the District Utility Permit Section is a good source of this information. Many cities have a service which contacts all the utility companies and requires only one telephone call. When those utilities which are present have been determined, each utility company should be contacted and requested to send a technician to locate their utilities in the digging area. Some utilities may prefer to expose their own lines. The responsibility for locating utilities usually rests with the Contractor, but the Inspector should make sure that all utilities have been located before digging begins.

Service poles should be installed according to the project plans unless field conditions indicate otherwise. If relocation is required, the Inspector should consider the location of the utility company power source, the location of underground utilities, the width of the right-of-way, and the location of the roadway ditch. Poles should never be installed at the bottom of the drainage ditch or anywhere water may collect in normal conditions. The service pole, like any fixed, non-breakaway obstruction

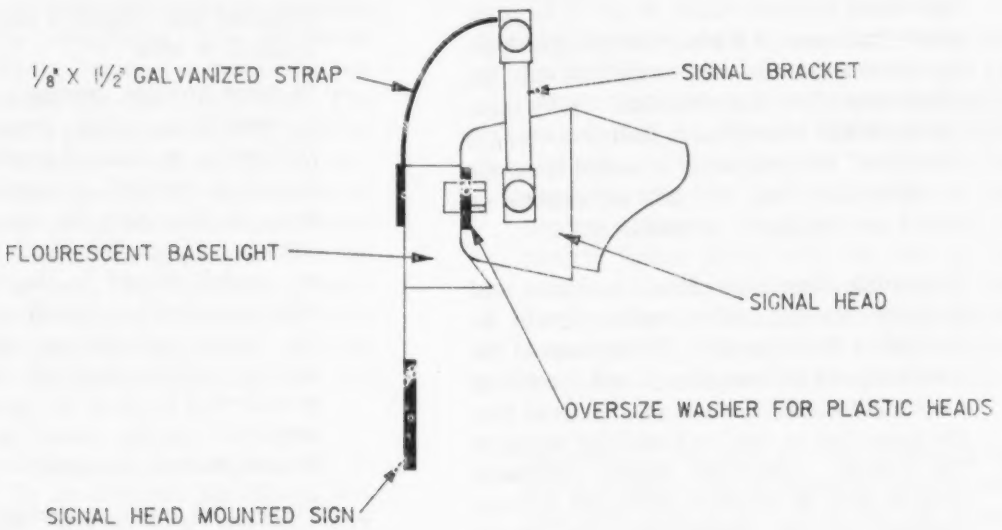


FIGURE 4-48

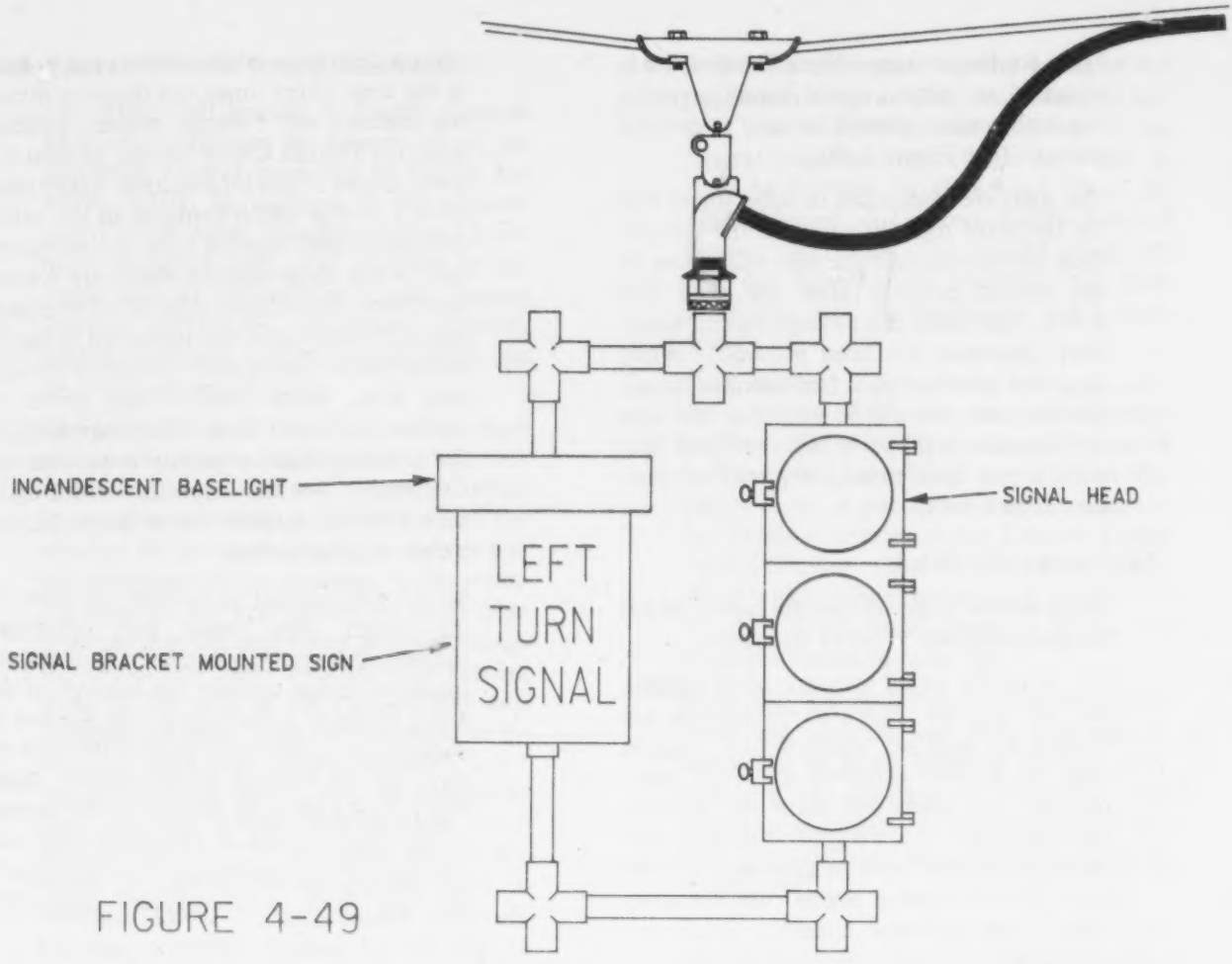


FIGURE 4-49

should not be placed within 30 feet of the pavement edge, unless it is protected by a guardrail. In urban areas with limited right-of-way, the plans may allow less clearance. Utility companies should be notified at least two weeks in advance of the time power is needed at the site to allow them time to make adjustments or install new equipment as necessary.

Trenching should be done in a neat and uniform manner. All trenches should be backfilled that same day. The bottom of the trench should be nearly level, and the wiring or conduit should be carefully placed so that the plans can be used to locate the wiring in the future. Trenching across driveways should only be allowed when the wire or conduit can be placed and the trench backfilled immediately. A trench through a ditch should be at least 24 inches below the bottom of the ditch. The plans or the Engineer may require a sand bed under the conduit or wire.

In some projects, boring may be preferred to trenching when crossing roadways, driveways, or railroad tracks. When a boring pit is required, it should be placed at least ten feet from the nearest edge of the roadway, if possible. Each end of the wire or conduit placed in the bore should be referenced both vertically and horizontally for future information. When boring is done on railroad right-of-way, advance approval must be given by the railroad. These approval requests should be made at least three months in advance.

Finally, all metal materials must be non-corrosive. The specifications will state what minimum protection is required, and the Inspector should be familiar with these requirements.

CHAPTER 5
Final Clean-Up, Inspection, and Test Reports

5.1 Final Clean-Up

Upon completion of the work of installing the traffic signals, and before acceptance of the project, the Contractor must clean and remove all rubbish and equipment on the highway right of way which is a result of the contract work. The Contractor must also remove all excess excavated material resulting from the construction of boring pits, drill shafts, controller pedestals, conduit trenches, or any other excavation required to complete the project. All materials removed must be disposed of at an approved location. Disposing of these materials on property adjacent to the highway will not be considered acceptable unless approved by the Engineer. All excavations should be landscaped to the existing contours of the groundline surrounding the work area.

5.2 Final Inspection

When the signals on the project have successfully completed their required test period and all work and clean-up has been satisfactorily completed, the inspector should notify the Engineer in charge that the project is ready for final inspection. The Engineer who is authorized in the District to make final inspections will be notified and the final inspection must be made within 10 days. After the final inspection and before the letter of notification of acceptance to the contractor is sent, the Inspector should make sure that the proper number of keys, wiring diagrams, and instruction manuals have been furnished according to the specifications.

Upon completion of the project or as established by an executed agreement, the agency with maintenance responsibility must be notified in writing that the project has been completed and the maintenance and operation of the installation has become their responsibility. Also, at this time, all manuals, wiring diagrams, and keys required to maintain and operate the signals will be given to the responsible agency.

5.3 Final Test Reports

The final test required for a signal installation project is to place the signals into continuous operation for a specified period. The signal must operate satisfactorily during this test period. The Contractor shall be advised when the test period begins. Minor failures such as a lamp failure, blown fuse, or a loop amplifier requiring tuning should not be considered as a basis for starting a new test period, if such minor failures are repaired immediately by the contractor and do not reoccur frequently during the remainder of the test period. A major malfunction or failure of the controller and its components is reason to restart the test period.

The inspector shall record the date the test period began, any failures, and the date the test was completed. If the test period had to be restarted due to major failures, the dates and reasons for restarting the test period must be recorded. Upon acceptance of the project, these records should be filed in the project folder along with test reports for supplies and equipment used during the project. Good records of test reports will be beneficial after acceptance of the project from the contractor, if unpredicted failures develop with the traffic controls.

Normal D-6 requirements are applicable for the documentation of material quality control tests when the project is being finalized.

CHAPTER 6
Glossary

This Glossary is divided into subject groups for the reader's convenience. The intent of this chapter is to provide a comprehensive dictionary of Traffic Signal terminology and therefore, contains many words not otherwise mentioned in this Manual.

6.1 Signal Heads and Mounting Hardware

BACKPLATE. A strip of thin material extending outward parallel to the signal face on all sides of a signal to provide a plain background for the signal indications.

BALANCE ADJUSTER. A device used to permit alignment of the point of suspension with respect to the center of gravity of the signal head so that the signal will hang vertically.

BEACON. A traffic signal of one or more faces consisting of one section each and used for flashing operation.

BRACKET ARM. A signal bracket, for bracket mount applications of tubular construction through which wiring can be passed to provide electrical connection of the signal faces.

CABLE. A group of separately insulated wires in a common jacket.

CABLE ENTRANCE ADAPTER. A device of tubular construction which is used between the span wire hanger and the signal to provide for passing signal cable into the head.

DISCONNECT HANGER. A mounting device for quick detachment or attachment of a signal head.

LANE USE SIGNAL. An overhead signal having indications that permit or prohibit the use of a specific lane of a roadway.

LAMP. The part of the optical unit which, when energized electrically, provides the optical unit light source.

BEAM CANDLEPOWER. The intensity of a beam forming light source expressed in candelas measured in a given direction.

BEAM SPREAD. The angle between the two directions in the plane in which the candlepower is equal to a stated percent (usually 10 percent) of the maximum candlepower in the beam.

BURNING POSITION. Physical positioning of the lamp in the traffic signal. Normally, traffic signal lamps are used in horizontal burning positions.

CANDELA. Unit of luminous intensity.

CANDLEPOWER. Luminous intensity expressed in candelas and specified as candlepower in a specific direction.

FILAMENT. The electrical resistance element heated to incandescence by electric current.

GLASS ENVELOPE. The bulb is designated by prefix letter(s) and suffix number(s). The prefix letter indicates the shape, while the suffix number indicates the maximum diameter of the bulb, expressed in eighths of an inch (does not apply to PAR type lamps).

LIGHT CENTER LENGTH (L.C.L.). The dimension, in inches (cm), from the center of the filament to the top of the base (including solder on the base eyelet).

LUMEN. Unit of luminous flux. Traffic signal lamp output is rated in lumens.

6.1 Signal Heads and Mounting Hardware (Continued)

MINIMUM "INITIAL" LUMENS. A minimum value of initial light output below which no more than a specified percentage of individual lamps will be permitted.

OVERALL LENGTH (O.L.). The total distance from the tip of the bulb to the tip of the base, including solder on the base eyelet (does not apply to PAR type lamps).

RATED "INITIAL" LUMENS. The average amount of luminous flux (light) produced by a statistically acceptable sample of lamps on operation at rated voltage after having been seasoned to one-half to one percent of rated life.

RATED LIFE. The (arithmetic) average of burning hours for a sample number of lamps operated at rated volts and defined operating conditions.

RATED VOLTAGE. The nominal or design operating voltage of the lamp; the voltage at which rated watts, lumens, and life are determined.

RATED WATTS. The average initial power (watts) consumed, when the lamp is operated at rated volts.

LENS. That part of the optical unit through which light from the light source and reflector passes and, in so doing, is redirected into a prescribed pattern and is filtered to a prescribed color.

MAST ARM. A structural support over the roadway extending from a pole, for the purpose of supporting signal heads.

MAST ARM, FLEXIBLE MOUNT. A mast arm mount where the signal head is attached to the mast arm by a flexible joint and connector to permit "free swinging" between the signal and the mast arm.

MAST ARM, RIGID MOUNT. A mast arm mount where the signal head is rigidly affixed to the mast arm to prevent any relative movement between the signal and the arm.

MESSENGER WIRE. A steel cable used to support signal equipment.

OPTICALLY PROGRAMMED SIGNAL. A signal head containing optical units projecting an indication which is selectively veiled so as to be visible only within desired viewing boundaries.

OPTICAL UNIT. An assembly of lens, reflector, lamp and lamp socket with the necessary supporting parts to be used for providing a single signal indication.

PEDESTAL. A vertical support on top of which the signal or controller cabinet is mounted.

PEDESTAL MOUNT. A signal head or controller cabinet mounted on top of a pedestal.

RAKE. Strain poles adjusted initially out of plumb but drawn to verticality under the span wire tensioning.

REFLECTOR. A contoured reflective surface which redirects light from the light source toward the lens.

SAG. The amount of deflection at the lowest point of span wire used for the mounting of signal heads.

SIDE MOUNT. A signal mounting arrangement where the signal head is mounted parallel to the vertical axis of a pole.

SIGNAL FACE. That part of a signal head provided for controlling traffic in a single direction. Turning indication arrows may be included in a signal face.

SIGNAL HEAD. An assembly containing one or more signal faces which may be designated as one-way, two-way, etc.

SIGNAL INDICATION. The illumination of a traffic signal lens or a combination of several lenses at the same time.

SIGNAL SECTION. The optical unit and housing capable of displaying an indication.

6.1 Signal Heads and Mounting Hardware (Continued)

SIGNALS. Optical devices which are electrically operated by a controller and visually communicate a prescribed action (or actions) to traffic.

ADJUSTABLE SIGNAL. A signal head having the signal faces mounted in the support hardware so that each face may be adjusted or "aimed," as required, to present the indication to approaching traffic.

NONADJUSTABLE SIGNAL (FIXED-FACED SIGNAL). A signal having the faces mounted in a casting so that the indications are presented at a fixed angle.

PEDESTRIAN SIGNAL. A traffic control signal which is erected for the exclusive purpose of directing pedestrian traffic at signalized locations.

SIGNAL SUPPORT. The physical means whereby a signal head is supported in a particular location.

SLIPFITTER. A mounting bracket which is used on the top of a pedestal.

SPAN WIRE HANGER. A mounting bracket for supporting a signal head by clamping onto a span wire.

SPAN WIRE MOUNT. A signal head suspended over the roadway on steel cable.

SPREADER, SOLID. A signal bracket having solid arms radiating from a bud and used at the bottom of a multiface signal.

SPREADER, TUBULAR. A signal bracket having tubular arms radiating from a hub through which wiring can be passed to provide electrical interconnection of the signal faces supported by the signal bracket.

STRAIN POLE. A vertical support to which span wire and hardware are attached for supporting traffic signals.

VISOR (HOOD). That part of a signal section which protects the lens face from direct ambient light and screens the indication from traffic not intended to view it.

CUTAWAY VISOR (CONTOURED, STANDARD). A visor which encircles approximately 300 degrees around the lens, the lower half of which is cut away and contoured.

FULL-CIRCLE TUNNEL VISOR. A visor which encircles the entire lens.

OPEN-BOTTOM TUNNEL VISOR. A visor which encircles the entire lens except a segment equal to approximately two inches of circumference at the bottom of the lens.

LOUVERED VISOR. A tunnel visor with inserted louvered device to cut off the signal's visibility from a direction where it is not desired to be seen.

6.2 Detectors

ACTUATION. The operation of any type of detector.

AMPLIFIER. A device that is capable of intensifying the electrical energy produced by a sensor.

DETECTIONS. The process used to identify the presence or passage of vehicles at a specific point or to identify the presence of one or more vehicles in a specific area.

DETECTOR FUNCTIONS.

CALLING DETECTOR (OR RELAY). A detector that is installed in a selected location to detect vehicles which may not otherwise be detected, and whose output may be modified by the controller unit.

CLASSIFICATION DETECTOR. A detector that has the capability of differentiating among types of vehicles.

DIRECTIONAL DETECTOR (OR RELAY). A detector that is capable of being actuated only by vehicles proceeding in one specified direction.

EXTENSION DETECTOR. A detector that is arranged to register actuations at the controller only during the green interval for that approach so as to

extend the green time of the actuating vehicles.

SAMPLING DETECTOR. Any type of vehicle detector used to obtain representative traffic flow information.

DETECTOR MODES. A term used to describe the duration of detector output when a detection occurs.

PASSAGE DETECTION. The ability of a vehicle detector to detect the passage of a vehicle moving through the detection zone and to ignore the presence of a vehicle stopped within the detection zone.

PRESENCE DETECTION. The ability of a vehicle detector to sense that a vehicle, whether moving or stopped, has appeared in its field.

PULSE MODE. Detector produces a short output pulse when detection occurs.

CONTINUOUS PRESENCE MODE. Detector output continues if any vehicle (first or last remaining) remains in the field of influence.

LIMITED PRESENCE MODE. Detector output continues for a limited period of time if vehicles remain in field of influence.

CARRYOVER (EXTENDED) OUTPUT. The ability of a detector to continue its output for a predetermined length of time following an actuation.

DELAYED OUTPUT. The ability of a detector to delay its output for a predetermined length of time during an extended actuation.

DETECTOR. A device to determine the presence or passage of vehicles.

LIGHT SENSITIVE DETECTOR. A detector that utilizes a light-sensitive device for sensing the passage of an object interrupting a beam of light directed at the sensor.

LOOP DETECTOR. A detector that senses a change of inductance of its inductive loop sensor caused by the passage or presence of a vehicle near the sensor.

MAGNETIC DETECTOR. A detector that senses changes in the earth's magnetic field caused by the movement of a vehicle near its sensor.

MAGNETOMETER DETECTOR. A detector that measures the difference in the level of the earth's magnetic forces caused by the passage or presence of a vehicle near its sensor.

PEDESTRIAN DETECTOR (PUSHBUTTON). A detector that is responsive to operation by a pedestrian.

PRESSURE SENSITIVE DETECTOR. A detector that is capable of sensing the pressure of a vehicle passing over the surface of its sensor.

RADAR DETECTOR. A detector that is capable of sensing the passage of a vehicle through its field of emitted microwave energy.

SONIC DETECTOR. A detector that is capable of sensing the presence of a vehicle through its field of emitted ultrasonic energy.

DIRECTIONAL RELAY. A relay connected with detectors and designed to actuate only when traffic has crossed the detectors in a certain direction.

LEAD-IN CABLE. The electric cable which serves to connect the sensor to the input of the detector unit.

PROBE. The sensor form that is commonly used with a magnetometer-type detector.

SAMPLING DETECTOR. A device which detects passage or presence of vehicles and transmits data to a computer for evaluation.

SENSOR. The sensing element of a detector.

6.2 Detectors (Continued)

ZONE OF DETECTION. That area of the roadway within which a vehicle is detected by a vehicle detector system.

6.3 Controllers - General

AUXILIARY EQUIPMENT. Separate control devices used to add supplementary features to a controller.

BANDWIDTH. The amount of green time available to a platoon of vehicles in a progressive signal system. Also referred to as through band.

BEACON FLASHER. A complete electrical mechanism for controlling the operation of a flashing beacon, including all necessary auxiliary apparatus.

CABINET. An outdoor enclosure for housing the controller unit and associated equipment.

CONFLICT MONITOR. A device used to continually check for the presence of conflicting signal indications and to provide an output in response to conflict.

CONGESTION DETECTION. A system of hardware and software designed and operated to provide data on the level of traffic congestion in the area being detected.

CONTROLLER (CONTROLLER ASSEMBLY). A complete electrical mechanism mounted in a cabinet for controlling the operation of a traffic control signal.

CONTROLLER UNIT (TIMER). That portion of the controller assembly devoted to the selection and timing of traffic movement at an intersection.

ANALOG CONTROLLER. A controller with a method of timing that measures continuous variables such as voltage or current.

DIGITAL CONTROLLER. A controller wherein timing is based upon a defined frequency source such as a 60-hertz alternating power source.

ELECTROMECHANICAL CONTROLLER. A controller which is characterized by electrical circuits using relays, step switches, motors, etc.

ELECTROMECHANICAL ELECTRONIC CONTROLLER. A controller combining electromechanical components and electronic timing circuits comprised of vacuum electronic tubes, resistors, capacitors, and inductors.

MASTER CONTROLLER. An automatic device for supervising a system of secondary controllers, maintaining definite time interrelationship, selecting among alternate available modes of operations, or accomplishing other supervisory functions.

MASTER-SECONDARY CONTROLLER. A controller for operating a traffic control signal and for providing supervision of other interconnected (secondary) controllers.

SECONDARY CONTROLLER (SLAVE). A controller which operates traffic signals under the supervision of a master controller.

INTERCONNECTED CONTROLLER. A controller which operates traffic signals under the supervision of a master controller.

NONINTERCONNECTED (ISOLATED) CONTROLLER. A controller for operating traffic signals not under master supervision.

SYNCHRONOUS-MOTOR CONTROLLER. A controller operated by a synchronous motor which maintains a constant speed determined by the frequency of the alternating current power supply.

COORDINATION. The establishment of a definite timing relationship between adjacent traffic signals.

CYCLE. Any complete sequence of signal indications.

6.3 Controllers - General (Continued)

CYCLE LENGTH (TIME CYCLE). The time required for one complete sequence of signal indications.

DECODER. A mechanism for translating a code into its various components.

DEMAND. The need for service; e.g., the number of vehicles desiring to use a given segment of roadway during a specified unit of time.

DENSITY. A measure of the number of vehicles per unit length of roadway.

DIAGNOSTIC. (1) Pertaining to the detection, discovery and further isolation of a malfunction or mistake. (2) A program that facilitates computer maintenance by detection and isolation of malfunctions or mistakes.

DIRECT WIRE. A communications medium which uses hardwire interconnect between the transmission and reception points.

DOWN TIME. The time during which a device is unavailable for normal operation.

FAIL-SAFE. A requirement that breakdown conditions or the failure of components shall not produce a dangerous condition.

FIELD TERMINALS. Devices mounted on the panel for connecting all wires entering the controller cabinet.

FLASHER CONTROL UNIT. A device used to open and close signal circuits at a repetitive rate.

FLASHER CONTROLLER. A complete electrical mechanism with cabinet for flashing a traffic signal or beacon.

FLASHING BEACON. A section of a standard traffic signal head, or a similar type device, having a yellow or red lens in each face, which is illuminated by rapid intermittent flashes.

FLASHING FEATURE. A relay or other device installed in a controller which, when energized from a remote point or by an automatic time switch, discontinues normal signal operation and causes the flashing of any predetermined combination of signal lights.

INDICATOR LIGHTS. Visual aids showing actuations and timing of intervals or phases on a controller for the purpose of programming, inspection, and maintenance.

INTERCONNECT. The communication network usually consisting of electrical cable connecting the system master with local intersection controllers.

INTERFACE. A common boundary at which two separate systems or portions of each join or interact. An interface can be mechanical, as in adjoining hardware surfaces, or it can be electrical, as in signal level transformation points. Moreover, it can also refer to human and machine interface and the interaction between man and computer.

INTERVAL. A discrete portion of the signal cycle during which signal indications do not change.

GREEN INTERVAL (RIGHT-OF-WAY). The operation of a controller in causing traffic signals to display indications permitting vehicles or pedestrians to proceed in a lawful manner in preference to other vehicles or pedestrians.

YELLOW CLEARANCE INTERVAL. The first clearance interval following the green interval right-of-way in which the signal indication for that phase is yellow.

RED CLEARANCE INTERVAL (ALL-RED). A clearance interval which may follow the yellow clearance interval during which both the terminating phase and the next green (right-of-way) phase display red.

PEDESTRIAN INTERVAL (WALK INTERVAL). A traffic interval allocated to pedestrian traffic which

provides a pedestrian right-of-way indication either concurrently with one or more vehicular phases, or to the exclusion of all vehicular phases.

PEDESTRIAN CLEARANCE INTERVAL. The interval during which the DON'T WALK indication is flashed, starting after a WALK indication and ending before conflicting vehicles receive a green indication.

INTERVAL SEQUENCE. The order of appearance of signal indications during successive intervals of a cycle.

INTERVAL SEQUENCE CHART. A chart designating the order in which the phases of a cycle occur and the associated signal display for each interval.

JACK. A receptacle in a controller cabinet in which a plug-in device may be inserted.

JACK MOUNTED RELAY. A relay equipped with a prong sub-base which may be removed or replaced without disturbing any wiring.

LOAD SWITCH. A device used to switch power to the signal lamps.

LOCAL CONTROLLER. A controller for operating traffic control signals at an intersection (or two or three proximate intersections) which may be isolated or included in a signal system.

MAJOR STREET OR MAJOR HIGHWAY. (Traffic Control Device). The roadway approach or approaches at an intersection normally carrying the major volume of vehicular traffic.

MANUAL OPERATION. The operation of a controller assembly by means of a hand-operated device(s) (manual pushbutton).

MANUAL PUSHBUTTON. An auxiliary device for hand operation of a controller.

MICROPROCESSOR. A device which uses the flexibility of computer electronics on a limited scale. Microprocessors are basically microminiaturized CPU's (Central Processing Units).

MINOR STREET OR MINOR HIGHWAY. The roadway approach or approaches at an intersection normally carrying the minor volume of vehicular traffic.

MOVEMENT. The travel direction and destination of a lane or lanes of vehicles at an intersection, i.e., left turn, through or right turn.

NOISE. Random variations of one or more characteristics of any entity such as voltage, current, and data. Generally, any disturbance tending to interfere with the normal operation of a device or system.

OCCUPANCY. The percentage of roadway occupied by vehicles at an instant in time. In general use it is a measurement based upon the ratio of vehicle presence time (as indicated by a presence detector) over a fixed period of total time.

PANEL. A board within the controller cabinet upon which are mounted field terminals, fuse receptacles or circuit breakers and other portions of the controller assembly not included in the controller unit or auxiliary devices.

PATTERN. A unique set of traffic parameters (cycle, split, and offset) associated with each signalized intersection within a predefined group of intersections (a section or subzone).

PERMISSIVE PERIOD. An interval during which a controller may yield the right-of-way from the arterial phase.

PHASE. Those right-of-way and clearance intervals in a cycle assigned to any independent movement(s) of vehicular traffic or pedestrians.

PEDESTRIAN PHASE. A traffic phase allocated to pedestrian traffic which may provide a right-of-way pedestrian indication either concurrently with one or more vehicular phases, or to the exclusion of all vehicular phases.

VEHICULAR PHASE. A phase which is allocated to vehicular traffic move-

ment as timed by the controller unit.

CONFLICTING PHASES. Two or more phases which will cause interfering traffic movements if operated concurrently.

NON-CONFLICTING PHASES. Two or more traffic phases which will not cause interfering traffic movements if operated concurrently.

NON-ACTUATED PHASE. A controller phase with no means for receiving actuations from vehicles and pedestrians.

PHASE SEQUENCE. The order in which a controller cycles through all phases.

POINT DETECTION. The detection of a vehicle as it passes a point or spot on a street or highway.

PREEMPTION. The transfer of the normal control of signals to a special control mode which may be required by railroad trains at crossings, emergency vehicles, mass transit equipment or other special needs.

PROGRAM SELECTION. The process of selecting the appropriate program for a given set of conditions. It can be accomplished manually or automatically either by time-of-day or in response to some characteristic or traffic flow.

PROGRAMMABLE READ ONLY MEMORY (PROM). A device that stores data which cannot be altered by computer instructions. Data is stored ("burned") into this device externally by an electronic process. Some PROM's can be erased and programmed through special physical processes.

RADIO INTERFERENCE SUPPRESSOR. A device inserted in the power line in the controller cabinet that minimizes the radio interference transmitted back into the power supply line, which interference may be generated by the controller unit or other mechanisms in the cabinet.

RANDOM ACCESS MEMORY - RAM. A storage device with both read and write capabilities which will allow random access to stored data.

READ ONLY MEMORY - ROM. A storage device not alterable by computer instructions, e.g., magnetic core storage with a lockout feature or punched paper tape. ROM requires a masking operation during production to permanently record programs or data patterns in it. Synonymous with nonerasable storage, permanent storage and read-only storage.

REMOTE FLASHING RELAY. A relay installed in a local controller which when energized from a remote point causes normal signal operation to be discontinued and specified signal lights to be operated in a flashing manner.

RESPONSIVE MODE. A system operation wherein the selection of signal timing programs is based on current traffic data as input by vehicle sensors within the network.

SIGNAL INSTALLATION. All of the equipment material involved in the signal control at one intersection.

SIGNAL SYSTEM. Two or more signal installations operating in coordination.

SIMULTANEOUS SYSTEM. A signal system in which all signals along a given street always give the same indication at essentially the same time.

ALTERNATE SYSTEM. A signal system in which alternate signals, or groups of signals, give opposite indications to a given street at the same time.

LIMITED PROGRESSION SYSTEM. A signal system in which the various signal faces controlling a given street give GO indications in accordance with a time schedule to permit (as nearly as possible) continuous operation of groups of vehicles along the street at a planned rate of speed, which may vary in different parts of the system.

FLEXIBLE PROGRESSIVE SYSTEM. A signal system in which the intervals at

6.3 Controllers - General (Continued)

any signalized intersection may be independently adjusted to the traffic requirements to give the maximum efficiency.

SOLID STATE DEVICE. A device characterized by electrical circuits, the active components of which are semiconductors to the exclusion of electromechanical devices or vacuum tubes.

SWITCH, AUTO-MANUAL. A device which, when operated, discontinues normal signal operation and permits manual operation.

SWITCH, FLASH CONTROL. A device which, when operated, discontinues normal signal operation and causes the flashing of any predetermined combination of signal indications.

SWITCH, POWER LINE. A manual switch for disconnecting power to the controller assembly and traffic control signals.

SWITCH, SIGNAL SHUT-DOWN. A manual switch to discontinue the operation of traffic control signals without affecting the power supply to other components in the controller.

TERMINAL BLOCKS, FIELD. Devices for connecting all wires entering the controller cabinet.

TIME SWITCH. A device for the automatic selection of modes of operation of traffic signals in a manner prescribed by a predetermined time schedule.

TIMER. (See Controller Unit).

TIMING CONTROL. A calibrated device that provides a time setting for an interval or portion of an interval.

TIMING ANALOG. Pertaining to a method of timing that measures continuous variables such as voltage or current.

TIMING, DIGITAL. Pertaining to a method of timing that operates by counting discrete units usually based on the frequency of the power source.

TRAFFIC ADJUSTED SYSTEM. A system in which an analog computer controls cycle length at special local controllers. Changes are based on threshold levels as sensed by vehicle detectors.

TRAFFIC RESPONSIVE SYSTEM. A system in which a master controller (analog or digital) specifies cycle and offset based on the real-time demands of traffic as sensed by vehicle detectors.

WEEKLY PROGRAMMER. A device used to determine the time of operation of programs on traffic control equipment according to a weekly schedule which may be preset to vary from day to day.

6.4 Pretimed Controllers

AUTOMATIC RESET. A reset by means of which the offset or beginning of the green indication is checked automatically and adjusted if necessary once each time cycle.

CAMSHAFT. A device consisting of a stack of programmed cams operated by a drive motor for intermittent advancement in increments to cause contacts to open or close, thus causing the required signals to be energized.

COMBINED MASTER AND SECONDARY CONTROLLER. A secondary controller equipped with auxiliary contacts for checking the offset and, when specified, means for accomplishing other supervisory functions over all secondary controllers in the system.

CONTACT, SIGNAL CIRCUIT. A device arranged to energize or deenergize signal light circuits during a specified interval.

CROSSOVER POINTS. The level of lane occupancy wherein the command function changes from one cycle length to another, or from one offset classification to another.

CYCLE LENGTH (TIME CYCLE). The time required for one complete sequence of signal indications.

6.4 Pretimed Controllers (Continued)

CYCLE SELECTION SWITCH. A device which when operated discontinues automatic selection of cycle unit with associated split(s) and offset(s), and permits manual selection of another cycle unit.

DUMMY INTERVAL. A redundant interval in the cam switching mechanism incorporated so as to allow the total number of intervals in the cycle to correspond integrally with the total number of intervals provided on the cam switching mechanism.

INTERLOCK. A feature of electromechanical controllers which maintains the timing dial in step with the camshaft.

INTERVAL SEQUENCE. A predetermined consecutive order of appearance of signal indications during seccessive intervals within a time cycle. It may also be referred to as the Color Sequence.

IN-TIME OPERATION. A specified timing relationship of the Go indication between controllers in a system of a traffic control signals in accordance with a predetermined timing diagram.

MASTER CONTROLLER. An automatic controller for supervising a system of secondary controllers, maintaining definite time interrelationship, or accomplishing other supervisory functions.

OFFSET. The number of seconds or percent of the cycle length that a defined time-reference point (normally the start of major street green) at a traffic signal occurs after the time-reference point of a master controller or an adjacent traffic signal.

OFFSET INTERRUPTER. A device which will distribute over two or more cycles the time required for large offset changes.

OFFSET SELECTION. Choosing one of several possible offsets manually or automatically either by time of day or in response to some directional characteristic of traffic flow.

OUT-OF-STEP. That condition of a traffic control signal installation belonging to a signal system when its operation does not possess the intended relationship to the system.

PEDESTRIAN SIGNAL. A traffic control signal which is erected for the exclusive purpose of directing pedestrian traffic at signalized locations.

PRETIMED CONTROLLER. A controller for the operation of traffic signals with predetermined and fixed cycle length(s), interval duration(s), and interval sequence(s).

RECOORDINATION. Restoration of the intended interrelationship of operation of signals in a signal system.

REMOTE CYCLE CHANGE. A mechanism applied to the timer of the master controller to make possible, by means of manual operation or means of an automatic time switch, a change in the total time cycle in operation at all local controllers interconnected within a signal system.

RESET. An adjustment mechanism applied to an automatic controller providing for the setting up of the timing arrangement of the start of the green traffic control signal indication.

SECONDARY CONTROLLER. An automatic controller for operating the traffic control signals at an intersection under the supervision of a master controller.

SIGNAL CONTACTS. A mechanism arranged to energize or deenergize signal light circuits during a specified signal color interval.

SPLIT. A division of the cycle length allocated to each of the various phases (normally expressed in percent).

SPLIT SELECTION SWITCH. A device on solid state controller units which when operated discontinues automatic selection of split changes which are independent of cycle length changes and permits hand selection of such split changes.

SYNCHRONOUS MOTOR CONTROLLER. An automatic controller operated by a

6.4 Pretimed Controllers (Continued)

synchronous motor which will maintain a constant speed governed by the frequency of the power supply circuit.

THROUGH BAND. The time in seconds elapsed between the passing of the first and the last possible vehicle in a group of vehicles moving in accordance with the designed speed of a progressive signal system.

TIMING DIAL. That part of a controller which times one cycle length and its associated split(s) and offset(s).

TIMER GEAR. One of a set of different diameter gears determining the cycle time of a timer dial when inserted into the drive train.

TRAFFIC-ADJUSTED MASTER CONTROLLER. A type of master controller designed to make continuous and automatic selection of cycle lengths, offsets, or other system operating features based on traffic flow information supplied to it from vehicle detectors located within the signal system.

YELLOW-RED FLASH TERMINALS. Terminals which are wired to give the operation of flashing either yellow or red on each traffic signal face by rearranging jumpers and/or field wires.

6.5 Traffic Actuated Controllers

ACTUATE. To provide a signal or impulse to a controller input which is intended to cause an event or sequence of events. Signal origination is from a separate source such as a detector, coordination device or a manual control.

ACTUATION. The operation of a detector in registering the presence or passage of a vehicle or pedestrian.

BARRIER (COMPATIBILITY LINE). A reference point in the preferred sequence of a dual-ring controller unit at which both rings are interlocked. Two reference points or barriers assure there will be no concurrent selection and timing of conflicting phases for traffic movement in different rings. Both rings across the barrier simultaneously to select and time phases on the other side.

CALL. A registration of demand for right-of-way by traffic (vehicular or pedestrian) at a controller.

CALLING RELAY. A detector relay which will allow a detector actuation to be transferred to the controller only when certain signal displays are occurring.

CHECK. An outgoing circuit that indicates the existence of an unanswered call.

CONCURRENT TIMING. (See Dual-ring Controller).

COORDINATOR (COORDINATION UNIT). A device used to inter-relate the timing of one controller to others in a traffic signal system.

MASTER COORDINATOR. A coordinator used to provide synchronization and selection of programs on secondary coordinators or pretimed controllers to maintain a traffic system.

SECONDARY COORDINATOR. A device used to supervise the cycle of an associated traffic actuated controller to permit synchronization and operation allowing passage of platoons of vehicles in a progressive traffic system.

DELAY RELAY. A detector relay which will provide an actuation only after the relay has been continuously energized for a set period of time.

DENSITY. A measure of the concentration of vehicles usually stated as the number of vehicles per mile per lane.

DUAL-RING CONTROLLER. A controller containing two inter-locked rings which are arranged to time in a preferred sequence and to allow concurrent timing of both rings, subject to the restraint in the Barrier (Compatibility Line).

DWELL. (See definitions from Rest).

ENTRY, DUAL. A mode of operation (in a dual-ring controller) in which one phase in

each ring must be in service. If a call does not exist in a ring when it crosses the barrier, a phase is selected in that ring to be activated by the controller in a predetermined manner.

ENTRY, SINGLE. A mode of operation (in a dual-ring controller) in which a phase in one ring can be selected and timed alone if there is no demand for service in a non-conflicting phase on a parallel ring.

EXTENDIBLE PORTION (EXTENSIBLE PORTION). (See Portions).

EXTENSION INTERVAL (GAP). The timing interval during the extensible portion which is resettable by each detector actuation. The green right-of-way of the phase may terminate on expiration of the unit extension time.

FORCE OFF. A command to the controller that will force the termination of the current right-of-way interval during the extendible portion.

GAP, MAXIMUM. The maximum time on volume density timed controllers allotted for vehicles to proceed through the intersection. The interval portion is decreased to a fixed minimum in proportion to traffic demands.

GAP, MINIMUM. The lower limit to which the extensible portion or terminating gap may be decreased on volume density timed controllers.

GAP REDUCTION. A feature whereby the unit extension in the phase having the green is reduced in the extendible portion of the interval in proportion to the time vehicles have waited on the phase(s) having the red (Volume density controllers).

HOLD. A command to the controller which causes it to retain the existing right-of-way interval.

INTERVAL. (See Portions).

LIMIT, EXTENSION. The maximum time of the extensible portion for which actuations on any traffic phase may retain the right-of-way after actuation on an opposing traffic phase.

LIMIT, MAXIMUM. The maximum green time after an opposing actuation, which may start in the initial portion.

MASTER CONTROL. Centrally located equipment designed to supervise a number of intersections and used to select programs on secondary control equipment to best suit traffic needs.

MAXIMUM GREEN. The maximum time of right-of-way can be extended by actuations on a phase provided an actuation has been registered on a conflicting phase.

MEMORY, LOCKING. The retention of an actuation for future utilization by the controller.

MEMORY NONLOCKING. A mode of actuated-controller operation which does not require detector memory.

MINIMUM GREEN. (1) The shortest time for which the right-of-way shall be given to a non-actuated phase. (2) The shortest time for which the right-of-way shall be given to an actuated phase provided an actuation has been registered for that phase.

MINOR MOVEMENT CONTROLLER. A device that can be used with a controller unit to provide subordinate phase timing.

MODULAR. Equipment which is designed such that functional sections are plug-in circuit boards and can be readily exchanged with similar units.

MODULAR CONTROLLER, BY FUNCTION. Controllers constructed so that additional functional capabilities may be provided by the addition of hardware modules. A single module provides a function(s) for one or more phases in the controller.

MODULAR CONTROLLER, BY PHASE. A controller constructed so that each timing module is associated with only one independent phase. The addition or removal of modules associated with one phase will not affect

the operation of the controller with respect to the other phases.

OVERLAP. A right-of-way indication when the right-of-way is assigned to two or more traffic phases.

OMIT, PHASE (SPECIAL SKIP, FORCE SKIP). A command that causes omission of a phase due to lack of an actuation on that phase.

PASSAGE (PASSAGE TIME). (1) The time allowed for a vehicle to travel at a given speed from the detector to the nearest point of conflicting traffic. (2) Also, a term functionally equal to and often used interchangeably with Unit Extension.

PASSAGE PERIOD. The time allowed for a vehicle to travel at a selected speed from the detector to the nearest point of conflicting traffic.

PEDESTRIAN RECYCLE. Pedestrian recycle is any start of pedestrian service after the start of the associated phase GREEN.

PHASE OVERLAP. Refers to a phase which operates concurrently with one or more other phases.

PHASE DIAGRAM. A diagram illustrating the sequence of phases at an intersection with movement arrows indicated for each phase and showing overlaps, concurrent timing, etc.

PHASE SEQUENCE. A predetermined order in which the phases of a cycle occur.

PHASE OMIT (See omit phase).

PORTIONS, INTERVAL. A discrete subdivision of an interval during which the signals do not change.

INITIAL PORTION. The first timed portion of the green interval in an actuated controller.

MINIMUM INITIAL PORTION (FIXED INITIAL PORTION). A fixed preset first interval portion of the right-of-way on volume density timed controllers.

COMPUTER INITIAL PORTION (ADDED INITIAL PORTION) (VARIABLE INITIAL PORTION). An initial portion which is added to the minimum initial portion in response to vehicle actuations on volume density timed controllers.

MAXIMUM INITIAL PORTION. The limit of the computed initial portion on volume density timed controllers.

EXTENSIBLE PORTION. That portion of the green interval on an actuated phase following the initial portion which may be extended by traffic actuations.

PREFERRED SEQUENCE. The normal order of phase selection within a ring with calls on all phases.

RECALL. An operational mode for an actuated intersection controller whereby a phase, either vehicle or pedestrian, is displayed each cycle whether demand exists or not. Usually a temporary or emergency situation.

RECALL, MAXIMUM VEHICLE. With the control activation, right-of-way is returned to the phase for the maximum green limit once during each cycle without the necessity for an actuation.

RECALL, MINIMUM VEHICLE. With the control activation, right-of-way is returned to the phase once during each cycle without the necessity of an actuation. Timing is for at least an initial interval portion and may be extended by succeeding vehicles.

RECALL, PEDESTRIAN. With the control activation, pedestrian walk and clearance intervals for the phase are timed once during each cycle without the necessity of a pushbutton actuation.

RECALL SWITCH. A manual switch which shall cause the automatic return of the right-of-way to a normally actuated

6.5 Traffic Actuated Controllers (Continued)

phase regardless of the absence of actuation on that phase.

REST. The interval portion of a phase when present timing requirements have been completed.

SERVICEABLE CONFLICTING CALL. A call which:

1. Occurs on a conflicting phase not having the right-of-way at the time the call is placed.
2. Occurs on a conflicting phase which is capable of responding to a call, or
3. When occurring on a conflicting phase operating in an occupancy mode, remains present until given its right-of-way.

SINGLE-RING CONTROLLER. A controller containing two or more sequentially timed and individually selected conflicting phases so arranged as to occur in an established order.

SKIP PHASING. The ability of a controller to omit a phase from its cycle of operation in the absence of demand or as directed by a master control.

SPLIT PHASE. That portion of a traffic phase that is separated from the primary movement to provide a special phase that is related to a parent phase and characterized by the inability to rest in a minor phase.

STOP TIMING. Provision within a controller to suspend timing operations upon assertion of an external command.

TIMING CONCURRENT. A mode of controller operation whereby a traffic phase can be selected and timed independently and simultaneously with another traffic phase.

TIMING, SEQUENTIAL. The arrangement of phases at multiphase intersections into a sequence in which the phases will occur consecutively.

TRAFFIC-ACTUATED CONTROLLER. A controller for supervising the operation of traffic control signals in accordance with the varying demands of traffic as registered with the controller by detectors or push buttons.

FULL ACTUATED CONTROLLER. A type of actuated controller in which means are provided for traffic actuation on all approaches to the intersection.

PEDESTRIAN-ACTUATED CONTROLLER. A controller in which intervals such as pedestrian WALK and clearance intervals, can be added to or included in the controller cycle by the actuation of a pedestrian detector (pushbutton).

SEMI-ACTUATED CONTROLLER. A type of actuated controller in which means are provided for traffic actuation on one or more but not all approaches to the intersection.

VOLUME DENSITY CONTROLLER. A controller used with detectors located a sufficient distance in advance of the intersection which makes use of vehicle actuation quantities and time-of-waiting of the initial vehicle to vary green interval portions for increased capacity and minimized delays.

YIELD. The action of allowing a semi-actuated controller, or a full actuated controller operating in the semi-actuated mode, to terminate the main street phase so as to begin satisfying existing cross street demand.

6.6 Computer Control and Interface

CENTRAL COMPUTER. A single central processing unit, auxiliary storage, input/output devices, interface units, and display equipment located at the central control point. This equipment will have all of the logic components used to determine the traffic signal control system as well as programs, to command the operation of local controllers, and the components for monitoring of a traffic signal control system and subsystem.

CENTRAL PROCESSING UNIT. A single

unit of a computer that includes circuits controlling the interpretation and execution of instructions.

CPU. Abbreviation for Central Processing Unit.

COMMUNICATION LINKS. Cable and interface units which may include multiplexing devices, to electrically interconnect all the various components in the traffic signal control system, including the central computer, the actuated controllers, arterial pretimed controllers, and all detectors. This term is used interchangeably with "interconnect" or "interconnect facilities."

COMPUTER. A device capable of accepting information, applying prescribed processes to the information and supplying results of these processes. It usually consists of input and output devices; storage, arithmetic and logic units; and a control unit.

COMPUTER PROGRAM. A series of instructions or statements in a form acceptable to the computer which will achieve a certain result.

CROSSOVER POINTS. The level of lane occupancy wherein the command function changes from one cycle length to another, or from one offset classification to another.

DEDICATED LINES. Communication lines used solely to interconnect two or more intersections.

ENCODER. A device which converts data into a form for transmission over the communication link between two points in a system.

FORCED-OFF OR FORCE-OFF. An operational procedure whereby the central computer causes a local controller to terminate one phase, and advance through the clearances to the next phase.

HARD COPY. A printed or typewritten record produced by a teleprinter or similar peripheral device.

INBOUND. The traffic condition wherein an imbalance exists with a heavier flow toward central points. This condition is also described as the a.m. peak period.

INPUT INFORMATION. The electrical signal produced by the detector in response to the movement or presence of vehicles within its sensing zone. Time of day, weather, and historical data may also be input information. Input data may also be inserted into the computer either manually or automatically.

INTERFACE. A common boundary at which two separate systems or portions of each join or interact. An interface can be mechanical, as in adjoining hardware surfaces, or it can be electrical, as in signal level transformation points. Moreover, it can also refer to human and machine interface and the interaction between man and computer.

LANE OCCUPANCY. A computer value derived from detector input data which serves to indicate the amount of street surface being utilized by vehicles in a single traffic lane. It is expressed as a percentage of time a detector is occupied over the total sampled time.

LOADER. A program that operates on input devices to transfer information from off-line memory to on-line memory.

MAIN STREET GREEN (MSG). An electrical signal transmitted from the local controller to the central computer during the period when the local controller is displaying green for the arterial phase.

MONITOR. An operating system software program which provides a uniform method for handling the real-time aspects of program timing such as scheduling and basic input/output functions.

MULTIPLEXING. A communications technique which allows more than one item of information to be transmitted or received at essentially the same time.

OUTBOUND. The traffic condition wherein an imbalance exists with a heavier flow away

6.6 Computer Control and Interface (Continued)

from the central points such as the central business district. This condition is normally a p.m. peak period.

SAMPLING DETECTOR. A device which detects passage or presence of vehicles and transmits data to a computer for evaluation.

SOFTWARE. The digital computer program providing the logic for control of the traffic signal system and subsystems.

SPECIAL TELEPHONE CONSTRUCTION CHARGE. One time charge to extend telephone lines from an existing point to a service point.

STANDBY. A mode of operation whereby the controllers operate independently of the central computer, usually in an emergency condition.

SURVEILLANCE. A process of observing traffic performance through the use of detectors.

TELEPHONE COMPANY. The telephone company designated on the plans as the company providing service for a communication network.

TELEPHONE INSTALLATION CHARGE. One time charge by the telephone company to place a telephone service terminal at a telephone service point.

TELEPHONE SERVICE POINT. Location at which telephone company connects to customer.

TELEPHONE SERVICE TERMINAL. Point of demarcation between telephone company and customer.

TELEPRINTER. A piece of central computer peripheral equipment, similar to a typewriter, used to supply data to the computer logic program and to provide hard copy records to program changes, alarms, and use of manual control.

USASCII. Abbreviation for United States American Standard for Informations Interchange.

6.7 Sign Lighting and Electrical Signs

BALLAST. A component used with lamps to control the current and to provide correct voltage for starting and sustaining operation.

BALLAST MOUNTING. Ballast may be mounted within the luminaire housing (integral); mounted in a weatherproof container attached to or beside the luminaire (contiguous); or mounted on the vertical support members (remote).

CONDULET. A fitting connected to solid or flexible electrical conduit to direct the routing path and containing a removable cover for wire pulling.

FLUORESCENT FIXTURE. A lighting unit containing a fluorescent lamp mounted within a housing with a metal framed plastic cover and a reflector.

MERCURY VAPOR LUMINAIRE. A lighting unit containing a mercury vapor lamp mounted within a housing with a metal frame glass lens and a reflector.

PHOTOELECTRIC CONTROL. An automatic switch controlled by ambient skylight intensity to turn sign lighting on or off according to the changes of night or day.

SIGN, CHANGEABLE MESSAGE. A sign on which the legend may be changed by the selective energizing of lamps arranged in a pattern, by the use of a rotating drum, or other methods.

6.8 Miscellaneous

APPROVED EQUAL. This term refers to a component offered by the contractor as equal to the one specified by catalog number or brand name in these specifications. A device or piece of equipment shall be accepted as approved equal only if approved by the Engineer.

BARRICADE. A portable or fixed barrier having object markings, used to close all or a portion of the right of way to vehicular traffic.

6.8 Miscellaneous (Continued)

BARRICADE WARNING LIGHT. A portable, power-operated, lens-directed, enclosed light used in either the steady burn or flashing mode to mark obstructions or hazards in construction and maintenance work areas.

CROSS WALK. (a) That part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or, in the absence of curbs, from the edges of the traversable roadway; (b) any portion of a roadway, at an intersection or elsewhere, distinctly indicated for pedestrian crossing by lines or other markings on the surface.

DELINEATOR. A light-reflecting device mounted at the side of the roadway, in series with others, to indicate the alignment of the roadway.

HIGHWAY, DIVIDED. A highway with separate roadways for traffic in opposite directions.

INTERSECTION. The area embraced within the prolongation or connection of the lateral curb lines, or, if none, then the lateral boundary lines of the roadways, of two highways which join one another at, or approximately at, right angles; or the area within which vehicles traveling upon different highways joining at any other angle may come in conflict.

Also, where a highway includes two roadways 30 feet or more apart, then every crossing of each roadway of such divided highway by an intersecting highway shall be regarded as a separate intersection. In the event such intersecting highway also includes two roadways 30 feet or more apart, then every crossing of two roadways of such highway shall be regarded as a separate intersection.

LANE USE SIGN. A sign indicating regulations governing use of specific lanes.

OBJECT MARKINGS. Markings intended for use on obstructions within or adjacent to the roadway.

RAISED PAVEMENT MARKERS (R.P.M.'s). Low profile housings incorporating recessed plastic inserts and convex bottoms with parallel ridges which are epoxy bonded to matching pavement positions prepared with an arbored concavity and saw cuts.

STEADY BURNING ELECTRIC LAMPS. A series of low-wattage yellow electric lamps used to mark obstructions or hazards in construction and maintenance work areas.

STOP LINE (or LIMIT LINE). A line which indicates where vehicles should stop when directed by a traffic officer or traffic control device.

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